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SCIENTIFIC REPORTS

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FOR THE YEAR ENDING JUNE 30, 1941

REPORT OF THE DIRECTOR

(B. VISWA NATH)

I. OUTSTANDING FEATURES OF THE YEAR

The work of the Institute during the year is described in the accompanying reports of the different Sections of the Institute, and they record steady progress. Two features of the activities during the year were—(1) The organisation and direction of an extensive campaign against locusts which had suddenly developed into a menace to crops and orchards in North-Western India, and (2) The large increase in the demand for advice on manuring field and vegetable crops, owing to the shortage in the supply of imported fertilisers.

II. RESEARCH AND INVESTIGATIONS—A QUINQUENNIAL REVIEW

It is now five years since the transfer of the Imperial Agricultural Research Institute (popularly known as the Pusa Institute) from Pusa to New Delhi in 1936, as the consequence of the damage to the Institute by the Bihar earthquake of 1934. On this occasion it will be appropriate to review the activities of the Institute in its new home during the past five years.

The effect of the transfer.—The reestablishment of the Institute in Delhi has given it a central position which is easily accessible from all parts of India. It has enabled that live contact with other scientific workers and with the main current of national life which is so necessary for the exchange of ideas and for enlarging breadth of vision and depth of insight.

The post-graduate courses given at the Institute have become more popular, and the central situation of the Institute has attracted a large number of honorary research workers and has enabled a much larger number to make use of the library and laboratory facilities available at the Institute.

Another feature is the development in the advisory and information service rendered by the Institute. In addition to the increase in consultative and advisory service in the analysis of soils, fertilisers and feeding stuffs, identification of plants, insects and fungi, and active co-operation with the Committees appointed by the Imperial Council of Agricultural Research, there has been a considerable increase in information service, which consists in providing the

latest and correct information on the subjects within the purview of the Institute. Thousands of letters are received each year asking for information of the most varied nature on matters concerning the science and practice of agriculture. The replies range from brief answers to carefully prepared reports.

It will be recalled that when the Government of India decided in 1934 to rebuild the Institute at Delhi, misgivings were felt in some quarters whether, owing to soil and climatic differences, the work on many important crops could be continued. The actual results obtained with several crops at Delhi belied these apprehensions. This fact and the retention of a sub-station of the Institute at Pusa has not allowed the continuity of field research and experiment to suffer by the change. The main station at Delhi, the outlaying substations at Pusa and Karnal, and the Sugarcane Station at Coimbatore which are financed by the Government of India, and the sub-stations at Simla and Guntur financed by the Imperial Council of Agricultural Research, provide widely-different climatic and soil conditions for the study of crops and agricultural practices.

Handicaps at the time of the transfer.—The transfer of the Institute from Pusa to Delhi coincided with the period which was marked by important developments and new ventures in agricultural research. In the agricultural industry itself there had been new developments. It was at that time that the Institute was under severe disabilities occasioned by the disastrous earthquake and by the loss from retirement of many of its senior and experienced workers. There was consequently unavoidable interruption to the activities of the Institute for four or five years before its transfer. The Institute had thus to begin its work in its new home under severe handicaps.

Internal organization.—As soon as the move was completed, and while the equipment of the laboratories and the layout of the agricultural land were in progress, an investigation was made of the existing organization and resources for post-graduate training and research. Proposals were submitted to Government showing the directions in which the resources should be strengthened in order that research and post-graduate instruction might be brought up to the standard expected.

The Government provided a temporary grant for a period of five years for financing the more urgent requirements. In addition to this, important omissions were supplied by appointing suitably qualified men for specialised work as vacancies occurred in the staff of the Institute. In this manner, the staff was gradually strengthened for work in experimental agriculture, plant-cytogenetics, plant physiology, soils, analytical chemistry, microchemistry, organic chemistry, spectroscopy, insect epidemiology, insect ecology and virus diseases of plants. The specific schemes of research financed by the Imperial Council of Agricultural Research provide for work on insect pests and diseases of sugarcane, for breeding potato and rust-resistant wheats, and for work on tobacco with particular reference to quality. Although there are still gaps to be filled for a complete modern central research station, the staff and equipment of the Institute have been gradually built up to meet many modern requirements in agricultural research.

Internal coordination of research.—The main functions of the Institute are two, viz., (1) post-graduate instruction and (2) research. The success or failure of an institution and its work, however carefully planned and however complete, will depend chiefly on the organization of the internal working to develop greater cooperation and coordination among the different research Sections on the one hand and for close contacts between the staff and research students on the other, and more important still is to encourage development of team spirit and to foster the development of corporate outlook and joint effort. Suitable organisations have been set up to secure these objects and they have been working satisfactorily.

A Staff Research Council consisting of senior officers and the Statistician has been set up, with the senior most officer as the Chairman, for planning and coordinating the research work in the different Sections of the Institute. The Council meets once a month, to discuss the progress of work and to suggest cooperative and collaborative investigations where a problem concerns more than one Section. When programmes were discussed and planned, the Vice-Chairman of the Imperial Council of Agricultural Research and the Agricultural Commissioner with the Government of India were invited to attend the meetings and the benefit of their advice and criticisms sought. Contacts between the staff and students are secured by sectional discussions once in a fortnight or a month and by general discussions once a month on themes in the science and practice of agriculture. These discussions are popular and are useful in enlarging the knowledge and outlook on the subjects discussed.

Post-graduate instruction.—Post-graduate training is an important activity of the Institute and has for its object the training of suitably qualified young men in methods of agricultural research to meet the demand for trained research workers. The courses of instruction have been modified to suit modern developments and requirements. Rules have been framed fixing the minimum period of attendance for the completion of the course. The Institute now confers the Associateship of the Institute (Assoc. I. A. R. I.) on those post-graduate students who satisfactorily complete the two-year course. In order to develop in the students the sense that they are creating something which they can claim as their personal accomplishment, the work has been adjusted to allow time for carrying out research, and for submitting it as a thesis in partial fulfilment of the requirements for admission to the Associateship of the Institute. The research work assigned to the student is ordinarily a part of the problem under study at the Institute, and such an arrangement has the advantage that, besides affording a training ground for the student, it assists in the progress of the main lines of research.

An advanced course in Animal Husbandry jointly given by the Imperial Agricultural and Veterinary Institutes was instituted in 1939-40.

Although an increase in the demand for post-graduate training was anticipated and hostel accommodation at Delhi was increased by fifty per cent compared to that at Pusa, the demand has become so large that several well

qualified applicants had to be refused admission during the past five years on grounds of limited accommodation.

	Number of applicants for post-graduate training	Number of post-graduates sent out after training*	Number of honorary Research Workers	Number of short course students trained
Quinquennium ending 30th June, 1936.	163	38	..	31
Quinquennium ending 30th June, 1941.	340	66	24	47

The programme of research.—The research activities of the Institute have a strong economic background and are directed to the study of the scientific principles underlying agricultural practices and improvements. A Central Research Institute is intended to ascertain the "Why" and "Wherefor" of an occurrence, a practice or a method, and to check the old and establish new standards of quality, measurement and methods. This type of work is basic to the more obvious and more easily understood " practical research ", and there is admittedly need for more fundamental principles and standards upon which reasoned experiments may be based for detailed local work, which directly concerns local agriculturists. It cannot, therefore, be too clearly stated that the research programme of the Institute cannot be a local or provincial affair.

Before planning the research activities of the Institute after its reestablishment at Delhi, a review was made of three decades' research in the different Sections of the Institute. The reviews were published in the Scientific Reports of the Institute for 1936-37. The survey and the reports by Sir John Russell and Dr. Nelson Wright on the work of the Imperial Council of Agricultural Research have been useful in knowing what was done by way of research and investigation on problems of crop and animal production, and in the planning of further research which is either a continuation or a corollary to what was done in the past or new additions as are necessitated by current problems and trend of developments. In selecting lines of research and planning programme of work every effort was made to avoid unnecessary duplication or overlapping with the work in any other part of India.

The natural desire to see quick and practical results from an agricultural institution's investigations should not be allowed to lessen, muchless shift, the emphasis on gaining knowledge. Without knowledge no improvement is possible. Knowledge has to be first acquired and then analysed and synthesised and suitably shaped before it finds practical application. The continuity of research and the accumulation of knowledge needs zealous guarding and more so in times of stress.

* Excluding those who left before finishing the course.

Details of the programme and progress of research and experiments during the past quinquennium will be found in the annual reports of the Heads of Sections published in past four years and in the appended reports for the year 1940-41. Some of these reports contain, besides the work of the year, summaries of selected investigations. Some of the lines of research have been published and several have reached the stage of publication and the results are being prepared to that end. The present review will deal briefly with the more important and significant researches during the quinquennium.

1. Mixed Farming—Basis of Soil Fertility.

The Institute is equipped with two farms at Delhi and Karnal, for work with animal power and mechanical power respectively.

An unexpected and interesting experience is that inspite of severe levelling in 1935-36, necessitating the removal of two to three feet of surface soil, the land at Delhi showed marked powers of recuperation, as will be seen from the yields of oats in plots Nos. 1, 2 and 3 of the main block.

	Yield of oats per acre in maunds (maund = 82·25 lb.)		
	1936-37	1937-38	1939-40
Plot 1	18·78	27·34	31·67
Plot 2	23·94	29·07	35·00
Plot 3	20·30	27·79	32·15

The principal lines of investigation in field agriculture are concerned with the study of the basis of agricultural practices with special reference to the improvement and maintenance of soil fertility.

Soil fertility is the most valuable national asset. It should be maintained where it is high, improved where it is poor and developed where it is lacking.

The theoretical or scientific aspect of soil fertility is an old problem in the chapter of agricultural research, but presents new lines from time to time. Research has advanced knowledge on the subject but has not yet given a precise scientific method for assessing, much less for predicting, the relative fertilities of soils. There is still lack of agreement between laboratory results on the one hand and practical results on the other. This is due, in most part, to the studies being limited to the soil and to the total exclusion from the studies of the other important and even more potent factors, the crop and its environment. Nevertheless, there is at present a great deal of general knowledge on the scientific basis of soil fertility, and although it is not yet adequate to predict accurately the fertility of soils, it is possible to ascertain the reasons for low fertility or infertility and to indicate ways and means of improving or restoring the fertility.

Soil fertility is of two kinds—permanent and temporary. Permanent fertility is inherent while temporary fertility is acquired by appropriate treatment. The response to extraneous treatment depends on the degree of permanent fertility, that is already there. Permanent fertility can be improved, maintained or impaired according to the systems and practices of agriculture that obtain. The basis of agricultural systems or practices is, therefore, an important line of study.

The initial success attained with crop yields early in this century by the introduction of high yielding varieties of crops, use of artificial fertilisers and by intensive methods of cultivation had for a time side-tracked field research in agriculture, and led to the belief that the problem of the fertility of Indian soils was solved. Experience has, however, shown that these improvements were temporary and were of little use in maintaining, much less in improving soil fertility, and that supplies of organic matter are essential for soil fertility.

This knowledge has brought about the realisation that soil fertility is the link between land and cattle, and that agriculture in India prospers or declines in proportion to its ability to evolve a system of agriculture and agricultural practices in which crop and animal husbandry are balanced. The solution, therefore, lies in the dovetailing of crop and animal husbandry into one system of mixed farming.

(a) Crop Husbandry.

The principle of mixed farming is that cattle support the land and land supports the cattle. The Institute believed in this principle from the very beginning. The data obtained at Pusa over a period of eighteen years show that, with little or no purchased fertilisers except phosphates and with the manure produced by the cattle, it was possible to increase and maintain the fertility of 413 acres of land and maintain 350 to 400 head of milch and working cattle on the grain and fodder raised on the land. In addition to the milk yield and to the increase in the number of cattle which were sold, the yields of grain and fodder over six rounds of rotations (three-year-six-course rotation) under rain-fed conditions were as below, between the years 1913-1930.

Yields in maunds per acre at each round of rotation over an area of 413 acres

	Maize grain	Pigeon-pea grain	Oats grain	Maize fodder
1st round of rotation . .	20·5	21·4	48·8	506·6
2nd round of rotation . .	28·4	26·4	48·8	571·6
3rd round of rotation . .	26·2	25·6	39·5	530·4
4th round of rotation . .	25·5	24·1	44·7	569·4
5th round of rotation . .	15·2	22·9	56·6	324·2
6th round of rotation . .	32·6	30·5	61·6	499·9

These experiments have been resumed and a new series of experiments have been laid out at Delhi and Karnal in areas of 300, 25, and 8 acres. These are expected to give information on the influence of the size of the holding on the reciprocal relations between land and cattle with reference to soil fertility and their influence on soil fertility.

Rotation of crops.—The rotation of crops has an important bearing not only on the business side of agriculture but also on the fertility of the land. This is particularly so with small holdings. Experiments were laid down in 1938-39 to investigate how far a holding of the size of 7·5 acres with live stock consisting of two bullocks, one milch animal with one or two young stock will increase and maintain the fertility of the holding under the mixed farming

system. The cropping scheme provides for the growing of maize, sugarcane, sorghum, cotton, as *kharif* (summer) crops and wheat, barley, peas and gram as *rabi* (winter) crops. Three types of rotations are adopted :—A four-year-eight-course rotation, a three-year-six-course rotation and a two-year-four-course rotation. A two-year-four-course rotation which included sugarcane failed to maintain the fertility of the land, while a three-year-six-course rotation improved it.

(*b*) *Animal Husbandry*

The Sahiwal milch cattle which were transferred from Pusa towards the end of 1936 soon settled down to their new environment. The experimental work continued on the lines so ably developed by Mr. Wynne Sayer, till recently the Imperial Agriculturist at the Institute. Mr. Sayer's work is of outstanding value in two respects. Firstly, he has shown the milk possibilities latent in Indian cattle and has successfully demonstrated the methods by which milk can be developed in the Sahiwal and Tharparkar breeds of cattle. Secondly, he has shown that by inducing early maturity in heifers and by judicious breeding, weeding, feeding and handling, the number of calvings and consequently the number of lactations and the total milk yield per lactation can be increased to economic levels without deterioration in the constitution of the animals or their progenies. The average milk yield of the animals in milk increased when at Pusa from 5 lbs. to 22 lbs. per day. There are now several cows in the herd which are giving in a lactation milk weighing ten to twelve times their body weight.

During the period of five years under review, a high standard of health, milk production and breeding was maintained by the herd. The general trend was towards further improvement in the herd, and no signs of deterioration in constitution or production as a result of early maturity and early mating and four times milking were apparent. As evidence of this fact, the following statements show (1) the percentage or numbers of animals under different categories of body weights of cows taken after calving and (2) the number of animals in various categories of milk yields, when the herd left Pusa in 1936 and in subsequent years at Delhi.

Percentage of cows under different body weight categories

Year	Total number for the year	Per cent of cows weighing above					
		600 lb.	700 lb.	800 lb.	900 lb.	1,000 lb.	1,100 lb.
At Pusa—							
1936 . . .	65	6·2	23·1	38·5	27·7	3·1	1·5
At Delhi—							
1937 . . .	66	1·5	6·1	21·2	48·5	18·2	4·6
1938 . . .	63	4·8	17·5	25·4	38·1	11·1	3·2
1939 . . .	70	2·9	18·6	24·3	35·7	17·1	1·4
1940 . . .	69	1·4	27·5	18·8	31·9	18·9	1·4

Number of animals in various categories of milk yields per lactation period of 306 days

Year	11,000 lb.	10,000 lb.	9,000 lb.	8,000 lb.	7,000 lb.	6,000 lb.	5,000 lb.
At Pusa—							
1935	..	..	1	6	4	5	11
1936	..	..	4	1	6	6	9
At Delhi—							
1937	1	1	3	2	1	4	9
1938	..	2	4	4	6	13	6
1939	1	1	1	4	6	6	10
1940	..	3	5	3	8	16	12

Cow Chansuri calved for the sixth time in November 1940 and yielded in one day 74 lb. of milk, and it is expected that in her present lactation her yield will be more than 12,000 lb.

There is definite evidence, that in the young stock, there is an increasing capacity for milk production founded on a constitutional development capable of bearing the high strain.

Early maturity experiments.—An important line of study is that on early maturity. Ordinarily mating is not allowed to take place until the heifers are $2\frac{1}{2}$ years old and the bulls attain the age of three years. This late mating, if due to late maturity, is a handicap in two directions. Firstly, the number of calvings and lactations and therefore the number of live stock and the total milk yield from a cow are smaller than what they can be, and, secondly, it would take at least nine years to test the performance of a bull's progeny and, therefore, the effective service period of a proved bull will be shorter than otherwise. Experiments were, therefore, started in 1932 to ascertain if late maturity was inherent in the breed and whether early maturity could be in induced by suitable feeding and handling. These experiments have proceeded steadily and there is now progeny from bulls 19 months old and heifers of about the same age. The data collected and the experience gained so far show that early maturity and early mating results in a great increase of time in profit to the breeder, i.e., the number of lactations, the live stock and the total milk yield in an animal's life are increased without affecting the animal in any way.

The average milk yield from early maturity animals has risen steadily from 13·6 to 21·9 lb. The average weights of animals at first covering time were of the order of 736 lb. and 637 lb. respectively for ordinary and early maturity animals. In subsequent lactations, this difference tended to even out as can be seen from the body weights of animals at the 22nd week of lactation.

	Control animals lb.	Early maturity animals lb.
First lactation	823	783
Second lactation	876	890
Third lactation	913	894

The available evidence also shows that early mating has not adversely influenced the development of the calf, and that newly born calves in successive calvings are in no way inferior to the calves born from late matings or controls.

	Control lb.	Early maturity lb.
Weight of calf at first calving	47·3	45·3
Weight of calf at second calving	50·2	50·2
Weight of calf at third calving	53·3	50·8

Feeding for milk yield.—The obviously relevant question is whether as the result of the high yields of milk produced by the animals the balance between the intake and outgo was being maintained by proper cropping for the maintenance of soil fertility and for the nutrition of the animals. This investigation particularly with reference to protein feeding is not neglected. In the case of very high milk-yielding animals, it is very difficult to make up suitable rations without unduly increasing the bulk and it is necessary to ascertain to what extent the usual concentrates can balance the income and outgo of nutrients. Considerable importance attaches to this study in connection with the studies on the breeding possibilities for milk and constitution.

The value of the results achieved so far can be gauged from the increasing demands from the public for the animals of Sahiwal breed. The sales of Sahiwal animals effected from the New Delhi herd during the quinquennium 1936-37 to 1940-41 are given below :—

	No. sold	Price realised Rs.
Bulls	16	9,250
Young Bulls	99	10,820
Cows	77	13,915
Heifers	6	710
Steerlings	21	609

2. Plant Breeding

(*a*) *Sugarcane*

The rapid and easy spread of Coimbatore productions has not only shown the value of markedly improved types for tuning up agricultural methods, but has also shown that in such cases the yield per acre scores over most other characteristics for ensuring popularity of a new type. Sugarcane breeding work would appear to indicate that most agricultural experiments and improvements are best linked up with the variety as the central factor. It is no more necessary to emphasize the great spread into cultivation in India of Coimbatore productions which today stands at over 75 per cent of the total area.

Sugarcane breeding at Coimbatore has become increasingly specialised for evolving " early " or " late " canes or canes resistant to diseases and pests. The demarcation line between medium and thick canes is getting fainter, each

type showing usefulness in tracts once assumed to belong to the other type of cane. This is because of the wider range of climatic and soil conditions in which the new canes are able to grow as a direct result of the range and nicety with which parents for crossing are selected.

Wide hybridization.—The very wide hybridizations which have been in progress are bringing into sugarcane breeding new genes and characters not available in the sugarcane group. Besides the inter-generic hybridizations with sugarcane, the inter sub-family hybridization between sugarcane and the bamboo should induce other crop breeders to make similar and parallel attempts. It would appear that the systematic position of plants should not deter breeders from attempting crosses between them. The inter-generic sorghum hybrids have yielded a few economic types like Co. 352 and Co. 356, the latter of which has been released for cultivation in Bihar after extensive mill tests.

Breeding technique.—In the matter of breeding technique, one of the important contributions has been the manner in which the time gap between the flowering of desired parents has been overcome by various means, such as (*i*) expediting or retarding flowering by artificial illumination with electric lamps and by planting the varieties at different times and under different soil conditions, and (*ii*) preservation of cane pollen in viable condition by suitable control of temperatures and humidities. The results show that mere disparity in the times of flowering in parents is no bar to raising hybrids between them.

Breeding resistant canes.—While the inheritance of external morphological characters in hybrid plants has received considerable attention from breeders, similar work on the inheritance of anatomical characters has been somewhat limited. This is perhaps because of such studies being more difficult and time-consuming. Anatomical studies of parents and their hybrids in sugarcane have not only indicated definite inheritance, but revealed useful correlations between such characters and pest incidence. The relative hardness of leaf midrib (on the lower side) has been noticed to be correlated with resistance to the top-borer (*Scirpophaga*). Such hardness has, in turn, been found to be the result of various anatomical characters, such as the thickness of epidermal layers, the number and distribution of vascular bundles and the relative cell thickness of vascular bundle sheaths, and studies have shown that these are inherited either singly or in combination. This is likely to place in the hands of sugarcane and other breeders a valuable method for breeding types resistant to pests.

Cytogenetic studies.—Cytogenetic studies have revealed the various factors responsible for the comparatively quick economic results from sugarcane breeding and the wide hybridizations that have been possible with sugarcane as the mother parent. These findings are likely to be of use in the breeding of other crops as well.

(*b*) *Crops other than sugarcane*

Wheat.—The major line of work in wheat is breeding for resistance against rusts and smuts, which are a menace to wheat growing.

The reaction to the different physiologic races of the three rusts that occur in India, is being tested every year both in the seedling and adult stages. A large number of the tested hybrids have given promise of combining disease resistance with desirable commercial characteristics.

A systematic search for suitable varieties for breeding purposes has resulted in the discovery of two varieties of the *vulgare* group from among a collection of wheats received from Kenya. These two varieties possess a high degree of resistance, one to the several races of black rust and the other to those of yellow rusts found in India. Though unsuitable for direct cultivation, they are invaluable for breeding purposes and crosses have been made between these and some of the Indian varieties. A complex cross was also made with the object of combining resistance to all the three rusts. The problem of resistance to smut diseases is next in importance to rust resistance. Reaction to smut infection of several varieties is being studied.

Two new improved varieties, I. P. 125 and a non-shedding strain of I. P. 120, deserve mention. The former has recently been released for cultivation, and very favourable reports are being received from different parts of India regarding its performance as an " all-round " wheat. I. P. 120 wheat, though otherwise very much valued, has the defect of shedding the grains. By careful selection three varieties which do not shed the grains have been isolated and from these three one has been selected which retains all the good qualities of the original I.P. 120.

Potato.—The work on this crop is being carried on both at the Sub-station in Simla and at Delhi. Before the commencement of this work a good deal of confusion existed with regard to the question of varieties, and it was not known what distinct varieties were represented under the common trade names. To clear up the position, a large collection of potato varieties from different parts of India, including commercial varieties, was grown, and after repeated elimination of duplicates the remaining small number of really distinct varieties were identified. This information was made available to the Agricultural Marketing Adviser to the Government of India.

In connection with the problem of resistance to Late Blight, recourse had to be taken to hybridization. Crosses made for this purpose between *Solanum demissum*, *S. Antipoviczii* and *S. tuberosum* have produced plants with very high resistance to the disease. Work has also been in progress with regard to the problems of Early Blight, viruses and frost. Extensive studies on the different kinds of sterility in potato have thrown light on this complicated problem.

Cytological and genetical studies.—An important feature of the quinquennium was the development of genetical research on cytological lines. Such a study, apart from its fundamental scientific interest, helps in tracing relationships between species and varieties of crops and leads to the evolution of altogether new races of plants through hybridization followed by the phenomenon of polyploidy. Polyploids are known to be often superior to the diploids, from which they originate, in important characters like plant size, yield, disease resistance and hardiness. At the Institute a number of polyploids and other chromosomal aberrations have either been induced, as in chilli (*Capsicum annum*), gram (*Cicer arietinum*) and *Brassicae* like *toria* (*Brassica campestris*) and *taramira* (*Eruca sativa*) or isolated from cultures (e.g. *chilli*,

toria, *rahar* (*Cajanus cajan*, etc.) These have been cytogenetically studied. Sterile hybrids from wide crosses, when treated with colchicine, double their chromosome complements and give rise to entirely new and fertile races. Experiments to induce such a change in two sterile interspecific hybrids of tobacco have been in progress.

At present the taxonomy of the group *Brassicae* is very much confused. The lack of standardized definition and nomenclature of the different species and varieties of *Brassicas* grown throughout India causes much inconvenience in their marketing. Even in the scientific world there is nothing to establish firmly the identity of the different species and varieties owing to a great range of genetic variability in them. Work is in progress to define such variability and to formulate for the group an adequate classification on cyto-taxonomical basis. Different genera, species and varieties belonging to this group have been hybridised *inter se* and cytogenetically studied. Many of the *Brassicas* are '*self-sterile*', i.e. refuse to set seed with their own pollen. The task of perpetuating any desirable character in a pure form is, therefore, nearly impossible. Detailed investigations were in progress to analyse the complicated phenomenon of self-sterility, especially in *toria*.

In connection with the above study two interesting and useful mutations have been isolated. One, an 'apetalous' *sarson*, lacks the usual bright yellow petals and is practically free from visits of insects that bring about cross-pollination. Moreover, the apetalous condition having been found to be due to a pair of recessive genes, it is easy to detect and 'rogue-out' any contamination in such a culture by simply uprooting the petalled 'rogues'. The other mutant, a 'closed-petal' *toria*, is similarly useful. Both of these mutations have been genetically studied and maintained as valuable breeding material. Combining any one of these mutant characters with factors for self-fertility would mean a big advance in the problem of self-sterility.

Hybrid vigour.—The investigations in this line are aimed at an elucidation of certain obscure points regarding the nature of the phenomenon on the one hand and its commercial exploitation on the other. Recent studies in wheat indicate that the expression of hybrid vigour is greatly influenced by external factors. The study has since been extended to other crops like chilli, gram and tobacco with the object of determining the optimum conditions for the manifestation of hybrid vigour. The results so far analysed in tobacco have given indications of increased vigour in the F_1 plants without the quality of the leaf being impaired in any way. The value of the method cannot be over-emphasized in a crop like tobacco where fairly large quantities of F_1 seed could be produced annually without undue waste of labour.

Vernalization.—This is one of the problems that has received attention in recent years. The results have shown that while the response to vernalization treatment is a varietal character, the degree of this response is influenced by environmental factors subsequent to sowing. Thus the Indian wheats are indifferent to pre-sowing temperature treatment and the English winter wheats show marked response to the treatment only when they are grown under long-day conditions. Several varieties of gram have been found to respond to the treatment in varying degrees when grown under field conditions. Experiments are now being designed to throw light on the fundamental nature of the problem.

3. Soil Investigations.

The research work on soils that has been in progress has the one aim of the establishment of basic principles for the utilisation of land to its full capacity without impairing its productivity.

Facts derived from an examination of the laboratory and field experience that has accumulated during forty years, indicated that the fundamental issue was the need for more comparative and co-ordinated information on the evolution and present status of soils as such with reference to geology and climate and in relation to crop growth. Many of the practical soil problems are admittedly governed by local conditions and are, therefore, best studied and solved locally, but there are still many directions in which knowledge on basic principles on a broad basis is required so that these principles may be applied to the study of local problems. The great age and maturity of Indian soils, the long settled agricultural practices and the experience gained in recent years show that problems of soil management and crop production should be viewed differently from what is based on experience elsewhere. There is, therefore, need for a new approach to the problems and to ascertain by comparative studies the geo-biological and bio-climatic influences on soil processes and in relation to agricultural practices and crop growth, so that the correlations and variations that emerge may be utilised for interpreting in a broad manner the response of vegetation in relation to soil types and under different conditions.

Soil maps of India.—A preliminary requisite to these studies is basic information showing different types of soils and the effect of a type of climate on different kinds of soils under that climate as also crop adaptation in relation to soil type and climate.

The available published and unpublished data have been worked up, and a map has been prepared showing the distribution of well-known types of soils. Another map has been prepared on the basis that the soil, irrespective of its geological origin, is the expression of the climatic influences on the soil. A third map has been prepared showing the distribution and adaptation of the major crops in relation to climate, to indicate the type of farming and agricultural practices that have developed as being the best adapted to the climatic factors.

These maps divide the country into four major climatic zones, *viz.*, arid, semi-arid, humid and perhumid zones, and bring out the dominant influence of climate on the characteristics of several types of soils of varied geological origin but developed under one climatic regime. The information given by these maps is of scientific interest and practical value. They show how the unique monsoon division of the year into dry and wet and how the relative intensities of rainfall, temperature and evaporation influence soil development and cropping systems. This information is useful in the scientific study of soil and the nutrition of crops and in crop planning. To mention one example, the problem of the plant-breeder is made more precise if he knows the soil and climatic types of the areas for which he is breeding new varieties.

Comparative soil studies and soil classification.—Closely associated with climatic classification, is the classification of soils, based on their important chemical and physical characteristics.

Indian soils and their agricultural systems are old and long settled. The accumulated experience through centuries and handed down from generation to generation of cultivators has resulted in assigning to soils local names descriptive of their characteristics and agricultural behaviour and which are understood by the agriculturists of the locality.

In recent years, new concepts of soil classification and soil nomenclature have come into vogue in Europe and America and aim at a unified system of world soil classification and nomenclature universally recognised and understood.

The classification and nomenclature of Indian soils needs thorough examination from the scientific point of view, which can not be separated from the agricultural point of view. In order to maintain the necessary contact between developments in soil science in India and similar developments in other countries it is desirable to fit, as far as possible, the terminology into the international nomenclature. At the same time, the variety of names which are in use in India and which are understood and recognised by the local agriculturists should not be ignored. It is necessary to define scientifically the local soil names, sort out similarities and differences, conveyed by the local names in different localities, and, where possible, assign international terminology to the name in local use.

With this object in view comparative soil surveys and soil studies were commenced. The studies consist of field observations including the examination of profiles of virgin and cultivated soils and laboratory investigations of the important soil characteristics. Certain conclusions that have emerged, from the studies thus far made, are of scientific and practical interest.

The most conspicuous features are the absence of profiles with horizones in the sense they are understood, the absence in many cases of close relationship between the soil and its rocky substratum, and the type of soil which developed in any given area was found to a large extent decided by the climate of that area. The climatic and the well-known soil zones on colour basis practically coincide in most cases. Compared with the soils of the temperate and colder regions, the atmospheric and soil temperatures in India are higher by as much as 10 to 20 degrees or even more. The chemical reactions involved in the soil processes are governed by high temperatures and humidity. The reactions proceed so intensively that chemical decomposition follows almost at the heels of rock disintegration. The result is that the forward reactions of normal weathering and the secondary reactions arising from the shifting equilibrium due to varying solubilities and interactions have tended towards the direction dictated by the climatic factors obtaining in the locality. For these reasons the genetic classification does not appear to be suitable, and classification based on climate as the predominant function assumes a particular significance especially for the soils of the plains.

The results of the chemical studies carried out so far have been useful in interpreting existing data on the response of crops to fertiliser applications,

phosphate fixation and to cultivation practices. The work when complete is expected to throw more light on such problems as irrigability of soils, alkaline and saline soils, soil erosion and soil fertility with reference to Indian conditions.

Investigations on alkaline and saline soils.—As a corollary to these studies on soils are the studies relating to alkaline and saline soils which occur extensively in certain parts of the country and not in others. They are a serious problem in Indian agriculture. Much is generally known about the generation of alkaline soils as the result of sodiumisation of the clay complex. It is generally believed that alkaline soils with a high pH and high sodium content are not formed in soils containing large quantities of calcium carbonate. Contrary to this belief alkaline patches have been noticed to develop in some plots at Pusa, where the soils contain as high as 40 per cent of calcium carbonate. New work has been stimulated by this observation, and the results of investigations carried out so far throw light on certain secondary reactions which are reflected in the composition of the clay complex in semi-arid and semi-humid regions in which alkaline and saline soils occur.

Minor or trace element status of Indian soils.—While there are considerable data on the major element contents of soils, there is no information based on the comparative contents of minor or trace elements. Even if the reserves of major elements like nitrogen, phosphorous, potassium, calcium and magnesium in the soil are adequate, the absence or non-availability of such elements as zinc, boron, copper and manganese can set a powerful limit on crop growth. Studies are in progress to assess the minor element contents of soils under different systems of cultivation, irrigation and manuring, and both spectroscopic and microanalytical methods are employed.

Soil tillage.—The ploughing of soil has hoary traditions behind it. Deeper and more frequent and more efficient ploughing is considered the best. Inversion ploughs of various makes are advocated as better substitutes for the country plough. Recently the question has arisen whether it is necessary or advisible to use the inversion plough in dry farming tracts. The examination of crop yield data over fifty years in respect of type of soil and quality of tillage shows that in many cases no benefit has been derived from intensive tillage, and in some cases it was even detrimental to soil conditions and crop yields. Investigation is, therefore, necessary to know (1) the principles underlying tillage, (2) which operations are essential for crop production and what factors determine the frequency of tillage, (3) the relationship between soil tilth and crop yield, (4) the type of implement and soil conditions that will bring about the relationship to the highest limit. Accurate knowledge in these directions is a prerequisite for the differentiation of the essential and non-essential or paying and non-paying operations.

Preliminary experiments have been laid down to determine the lines of investigations. The results of comparative tillage experiments in two seasons with the Victory plough (inversion) and the country plough have shown no significant differences in crop yields. Laboratory studies show that the result of intensive ploughing appears to be destruction of organic matter and intensifying nitrification. There is also considerable nitrogen fixation but this is accompanied by correspondingly high nitrogen losses. Another important

point of study is to what extent irrigation and manurial and fertiliser treatment can obviate the adverse effects of intensive tillage.

Tractor tillage experiments are also in progress to secure information of a scientific and economic nature to determine whether the tractor is a sound proposition in general cultivation. Information has been obtained on the capacity of different tractors for ploughing, disc-harrowing, grubbing, rolling, drilling operations and the cost of the several operations per acre. The current experiments are designed to obtain information on the (1) effect of tractor ploughing in successive years on soil fertility and economics of crop production and to ascertain the extent to which manuring and irrigation counteract the tendency, if any, towards decline in fertility, (2) whether continous tractor use would result in the undue compacting of the sub-soil.

Soil water and soil moisture.—Of all the limiting factors in Indian agriculture water is the principal one. The problems concerned with soil water and soil moisture are therefore of particular interest. There are several problems connected with soil moisture in relation to crops under dry-farming with low and deficient supply of water, under irrigation farming with regulated and optimum water supply and under puddled conditions with plenty of water supply. Apart from scientific studies to ascertain the different states in which water is absorbed and held in soils having different cationic composition of clay and its ability to deliver water to the growing crop, investigations are in progress to ascertain, under dry-farming conditions, the relation between the depth of penetration of water into the soil and the minimum moisture depth required to produce grain having regard to atmospheric conditions and evaporation and transpiration. The object is to ascertain the amount of irrigation and rainfall necessary to produce grain. Having ascertained this critical amount which is on the border line between grain or no grain, the next step is to ascertain the relation of small increments over the critical amount to the quantity of grain produced. In this connection the effect of puddled conditions either as the result of heavy rainfall or cationic composition of clay, on soil and the time taken for normal conditions to be restored are also under study.

The microbiological, physico-chemical and yield aspects of soil fertility.—The importance of the study of soil fertility or productivity from the biological point of view cannot be over-stated. It is of particular value to the majority of Indian soils, as it opens up possibilities of dealing more successfully with the maintenance of soil fertility having regard to the climatic conditions that obtain in the country.

In the past much attention has been given to the subject of nitrification and nitrogen fixation in soils, and a large amount of work has been done on the relationship between root nodule bacteria and leguminous host plants. From the results of these investigations we have now knowledge of the processes involved and of controlling them to economic ends. It is known that whatever factors accelerate, retard, or arrest plant growth, exercise a similar effect on the microbiological population of the soil. There is, however, no information on the nature, numbers, and physiological reactions of organisms under low and high fertility as judged by crop yields and on the effect of crop rotations, particularly the introduction of a leguminous crop in the rotation.

This study was initiated in the permanent manurial plots at Pusa. The plots selected for the studies are those that have been for about thirty years under differential fertiliser and manurial treatments. The results obtained thus far indicate a faint correlation between *rabi* crop yields and numbers of micro-organisms and their physiological activity, but no consistent relationship is seen between the microbiological population, bio-chemical activity and crop yield in the case of *kharif*. Samples collected in the months of May and July showed loss of nitrogen on incubation for two months, while samples collected in October showed fixation of nigtrogen.

4. Manures and Fertilisers

Soil nitrogen.—The supply of nitrogen to soils is an economic problem of great importance to Indian agriculture. While past research has shown the methods of utilising available sources to greater advantage than hitherto, facts derived from studies have shown that large losses of nitrogen occur from the soil, more so on the addition of nitrogenous fertilisers. The significance of loss needs investigation particularly in view of the fact that nitrogen supply is the most necessary and expensive part in manuring crops in India. The results of lysimeter or drain-gauge of nitrogen balance in soil with and without cereal and leguminous crops and with the addition of green manure are under examination. The studies include analysis of soils, drainage waters and crops. The object is to ascertain to what extent productivity can be maintained by crop rotations alone.

On the field scale a series of fertiliser experiments have been laid to ascertain the efficiency of fertilisers and manures added to the soil. The efficiency will be judged by recoveries of added fertilisers in crops. Studies on nitrogen transformations in the soil have shown that, in addition to loss through leaching and as ammonia, loss of elemental nitrogen also occurs, and that the gain by fixation of nitrogen is offset by another process which allows nitrogen loss to take place. It has been ascertained that although the total nitrogen content of Indian soils appears to be disconcertingly low, its availability as indicated by ammonification and nitrification is as high as 10 to nearly 50 per cent of the total nitrogen, while in the soils of the temperate and colder regions the availability is as low as one per cent of the total nitogen. This quick availability explains why in India soils containing as low a nitrogen content as 0·03 to 0·05 per cent grow good crops. The question is how the balance of this low nitrogen is maintained, if it becomes available so quickly. A study of the carbon-nitrogen transformations has brought into relief a newer and clearer picture of the carbon and nitrogen cycles. These cycles are reciprocal in nature and the equilibrium and balance are maintained through oxidation and reduction processes that result from microbiological activity and from purely physico-chemical reactions. The latter have been shown to be brought about by direct energy transfers leading to the fixation of nitrogen or carbon according to conditions.

In regard to loss of nitrogen, which is distinct and separate from nitrogen fixation, it has been ascertained that the loss occurs when highly nitrogenous substances are added to the soil in the absence of energy materials. Thus the loss of nitrogen is greatest with ammonium sulphate and least with farm-yard

manure, and in the case of the latter even fixation of nitrogen occurs. These observations raise the interesting and important problem whether it is desirable to carry out composting processes to an advanced stage at which practically all energy or carbohydrate is consumed. The explanation for the lower or even adverse results with composts that are sometimes obtained in comparative experiments with farm-yard manure may possibly lie here. This is under investigation.

Fixation of nitrogen by crops.—Studies on the fixation of nitrogen by crops have brought out two facts. One is that even a reputed crop like berseem (*Trifolium alexandrinum*) fails to enrich soil with nitrogen if more than two or three cuttings are taken. The other fact is that even cereal crops like maize fix atmospheric nitrogen in the soil. The evidence so far available shows that fixation by the maize plant is due both to the stimulation of nitrogen-fixing organisms in the soil by the root secretions of the maize plant and by the maize plant itself. No specific organism in the plant associated with nitrogen fixation has been found yet.

Associated with the subject of nitrogen fixation by crops is the study of bacteriophage. Root nodules of several leguminous plants have yielded bacteriophages capable of dissolving strains of nodule organisms. Among non-leguminous plants maize roots have yielded a bacteriophage which is less active than that from the nodules of leguminous plants but is capable of dissolving cultures of berseem and *Lathyrus* root nodule organisms. Continuing the investigations started at Pusa, it was observed that while bacteriophage could be isolated from berseem at Pusa, it could not be done from berseem grown at Delhi. Investigations of a wider and more extensive character have given unexpected results. No bacteriophage could be detected in berseem grown either for the first time or in rotation once in three or four years, while bacteriophage was evident in nodules of berseem grown continuously in a field for several years. If further work confirms these observations, it will provide an explanation for berseem sickness and its failure to enrich the soil nitrogen.

Phosphatic fertilisers.—Next in importance to nitrogen is the question of phosphates in crop production. A knowledge of the comparative powers of fixation of phosphates by different soil types, is necessary for the intelligent and economic use of fertilisers with respect to the amount, kind and effectiveness. From the standpoint of soil types the manner in which added phosphate is held up or made available to crops, furnishes an important correlation and clue to the processes of eluviation of iron and aluminium in soil profiles and in differentiating closely related soil types. In the peninsular part of India, red, black, yellow, brown and grey soils occur. The variability appears to be due to different states of hydration of the oxides of iron, the black type being the most hydrated, yellow intermediate and red the least. In conformity with this postulation red soils usually occur on higher levels, yellow at intermediate levels and black below the two levels. Comparative fixation experiments with phosphate are useful not only in differentiating soil types but also in throwing light on the phosphate fertilisation of soils.

The investigations on the phosphate-fixing character and capacity of different soil types have shown that soils of the semi-arid and humid zones fix the greatest amount of phosphate added in the form of diammonium hydrogen phosphate, while the soils of the arid zone fix only two-thirds of this quantity. Those of the per-humid zone show the least amount of fixation, the quantity fixed being less than half of that fixed by the soils of the semi-arid zone. On the basis of colour classification the largest amount of phosphate is fixed by black soils, while the brown, red, pink and grey soils fix about two-thirds of the quantity fixed by black soils. Other relationships such as pH, clay content and base exchange capacity to phosphate fixation, as also the significance of fixation in practical fertiliser problems, are under investigation.

Storage and fermentation of farm-yard manure.—The storage and fermentation of daily accumulations of farm-yard manure (dung+urine+litter) is a problem of considerable agricultural and public health importance in the tropics. The agricultural importance is well recognised but the public health problem has come into prominence after we came to Delhi. The storing of daily collections by the usual methods encourages fly breeding, particularly in warm months. The municipal and district health authorities insist that the daily accumulations should be covered by a layer of earth about one foot thick and thoroughly compacted by ramming to prevent fly breeding and escape of maggots. There are two difficulties in carrying out this in practice. In the first place it may not be possible in farmsteads to find the earth and the time required, and, secondly, the manure does not ferment properly and does not benefit crops.

The problem of storage to prevent fly breeding is being investigated in two ways. In one method all dung and litter collected is stored in long shallow trenches (10 feet wide and 4 feet deep). The daily collections are covered with gunny soaked in coal tar. The gunny is shifted after seven to ten days and the manure is covered with a layer of earth. The heat generated by the manure under the gunny is sufficient to kill most of the larvae which are caught under the tarred gunny. This method has so far been found to be effective without affecting the quality of the manure.

The other method is the anaerobic fermentation of the manure. The investigation consists in first establishing a baterial seed-bed and making daily additions of fresh dung and litter. The gases that escape are collected and analysed to see if any nitrogen is contained in the escaping gases. This has not been found and all the nitrogen of the added materials has been conserved in the residual manure. The manurial value has yet to be tested. If this is found not to have been impaired, the effect of dropping the collections into deep pits will be investigated with a view to simplify the storage in practice. The gases that evolve are all fuel gases and if the quantities produced are sufficiently large, they can be used for other purposes.

The activated sludge method of converting sewage into manure.—An activated sludge plant has been installed at the Institute for the disposal of the sewage of the Institute estate. The equipment is used for the scientific study of the whole question of converting sewage into manure. If this is satisfactorily

and economically achieved in India, it would provide a means of disposing of the habitation wastes in large towns in a compact area, and with financial returns to municipalities. The lines of study are (1) the quickest way to produce maximum sludge formation, (2) the fertilising value of the sludge, (3) the economics of the whole system, (4) the influence of the sludge manure on the growth, composition and quality of crops.

5. Plant Nutrition

There is one aspect of soil fertility about which more information is urgently required and that is on plant nutrition. Studies on soil fertility have so far been confined mostly to investigations on soils and to improvements in known processes for the determination of physical, chemical and microbiological properties and for the estimation of the total and available nutrients of the soils. The ultimate measure of soil fertility being crop yield, it is obvious that it depends not only on the nutritional requirements of plants but on their capacity to extract from the soil water and nutrients from the soil and the atmosphere. Differential response of crops due both to differences in soil types and to differences in varieties should be capable of being separated to better understand soil fertility. Work on the nutritional requirements and nutritional capacities of widely separated and closely related crop plants is necessary before the knowledge on soils is put into greater practice.

The studies on varietal differences in plant nutrition have been receiving attention, the crops under study being wheat, maize and sugarcane, and the data so far obtained indicate that differences in water absorption, germination and nutrient absorption are due more to varieties and environment than to soils. In wheat absorption of phosphate is greater at a temperature of 10° C. than at 31° C., while the reverse is the case with maize or millet. In sugarcane differential absorption of lime and phosphates has been observed.

The fundamental issue in plant nutrition and plant growth is the initial availability and capacity to manufacture the physiologically active constituents called auxins. The recent discoveries that certain organic manures contain these physiologically active constituents and their presence and distribution in plant tissue has stimulated research on the effect of manures and fertilisers on plant growth and metabolism, and the results obtained are of value in adopting a rational manurial policy.

Closely associated with the studies in plant nutrition are investigations connected with food crop production for national nutrition and health. Without adequate nutrition, hygiene alone cannot maintain efficiency and check disease. The research that has been in progress has shown that crops grown under certain conditions are more nutritious than similar crops grown under other conditions. This is new knowledge and the consequences are far-reaching.

The questions from the agricultural point of view are : (1) what crops should be grown for food ? (2) How they should be grown ? The answer to the first question is to be obtained by classifying food crops (cereals, pulses, oil-seeds, tubers and roots, vegetables, fruits, fodders and hays) on the basis of their calorific value, protein, vitamin and mineral contents. The answer

to the second question is to be had from the investigation into the variations in the composition and biological values of the crops under different environmental conditions and manurial treatments.

Well-known types of Imperial Pusa wheats which are extensively under cultivation have been under investigation. There are, as would be expected, differences in chemical composition and nutritive values due to varieties, but differences induced by environment and manurial treatment have been found to be too big to need examination. The nature of manurial treatment has induced changes in the vitamin and protein complexes with the concomitant changes in the nutritional and technological values of the wheats.

Studies in the phosphorous fractions in wheat and peas grown with different manures have been made. A greater part of the phosphorous is in the form of phytin which is said to be almost unavailable in so far as human nutrition goes. When grown with mineral phosphates only, nearly fifty per cent of the phosphorous in the grain is in the form of phytin. With organic manures, singly or in combination with mineral phosphate manures, the phytin content of the grain is much less and is of the order of 25 per cent.

These studies have opened up a wide and new field for investigation to ascertain suitable systems of manuring to secure optimum yield and nutritive value in the resulting crop for the benefit of human and animal nutrition.

6. Investigations on Agricultural Produce and Industries

A new and significant development which affects the grower is in regard to chemistry in relation to specific qualities and standards demanded by trade and industries in the agricultural produce with which they deal. As examples may be cited the investigations in progress with respect to milling and baking qualities in wheat, malting qualities in barley and millets like *jowar*, starch qualities in tubers and roots, standards for cigar, cigarette, hookah, and chewing purposes in tobacco, qualities for *gur* and sugar manufacture in sugarcane, and insecticidal value of tobacco, pyrethrum and other plants.

Formerly empirical tests have been in use for assessing the different standards required for different commodities. Biochemical studies of what is meant by quality in agricultural produce are now providing scientific criteria and explanation for several of the empirical tests. Quality in several instances is reflected either directly in the chemical composition, such as proteins, and other nitrogen compounds, carbohydrates and minerals, or indirectly by the ratios of the constituents. A knowledge of the chemical composition with respect to quality factors induced by cultural, manurial and environmental conditions is of value in advising growers how to meet the demands for quality.

Studies on the chemistry of sugarcane to ascertain the nature of the constituents affecting colour, structure and keeping quality of *gur* indicated that the ratio of organic non-sugars to sucrose affects the quality of *gur* more than the ash constituents of the juice. In cigarette tobacco investigations the indications are that quality and flavour appear to be associated with the ratios of nitrogenous products and carbohydrates on the one hand and the ash constituents on the other.

Research in agricultural chemistry should not end with the study of the problems concerned in the raising, harvesting and storage of crops. Everything raised on the farm should be considered as being potentially valuable either as food or as raw material for industry. The investigation of the technical and economic questions in the use of agricultural produce particularly on village or cottage industry basis and in the production of finished or intermediate products, is of considerable importance in the economic development of agriculture and the agriculturist.

The investigations that have been in progress are on the conversion of such waste materials as rice husk into active carbon and its use in the manufacture of better quality *gur* and white sugar by the open pan process and in cleaning and refining oils, on the methods of flue-curing tobacco, preservation of vegetables, preparation of starch and its conversion into glucose, conversion of sugarcane juice and molasses into gum. Some of these have passed the investigation stage and are on trial in different parts of the country, while others are promising of results.

7. Diseases

Testing of crops for disease resistance.—Attempts are being made to find disease-resistant types of no less than seven crops, namely, sugarcane, wheat, oats, pigeon-pea, sannhemp, gram and potatoes.

In sugarcane, varieties are being sought which are resistant to red-rot (*Colletotrichum falcatum* Went), wilt (*Cephalosporium Sacchari* Butler) and Smut (*Ustilago scitaminea* Sydow). While it is yet not possible to say that any particular variety is entirely satisfactory from the point of view of disease resistance, it is possible to name a number which are highly susceptible. Among these, Co's. 213, 223, 244, 299, 331, 362, 419 and 445 and Co. K. 10 have been consistently heavily attacked by red-rot; Co's. 213, 223, 290, 312, 331, 352, 421, 441 and 442 by wilt, and Co's. 362, 417, 433, 513, 524, 526 and 532 by smut.

In wheat, resistance to loose smut [*Ustilago Tritici* (Pers.) Rostrup] and flag smut (*Urocystis Tritici* Koern.) has been tested. The varieties I. P. 114 and 124 appear to be immune to loose smut and I. P. 120 and I. P. 121 highly resistant, while a number of well known varieties, such as I. P. 4, I. P. 52, I. P. 80-5, I. P. 111, I. P. 125, Punjab 8A, Punjab C. 518 and Cawnpore 13 are very susceptible. The variety Federation, a parent of some of the Imperial Pusa varieties, is immune and has transmitted its character of resistance to its offspring. It has also proved possible to secure resistant strains from selections of healthy plants in varieties heterozygous for resistance. I. P. 114, I. P. 120, I. P. 121, and I. P. 124, varieties of wheat which are so resistant to loose smut, proved very susceptible to flag smut. On the other hand, I. P. 4, I. P. 80-5 and I. P. 111, which were highly susceptible to loose smut, were fairly resistant of flag smut.

Amongst sixty Indian and foreign varieties of oats tested, none of the Indian varieties was found to be immune, but one hybrid between an Indian and a foreign variety proved to be immune and another highly resistant to covered smut caused by *Ustilago Kolleri* Wille. It may be noted that all the foreign varieties belonged to *Avena sativa*, whereas the Indian (susceptible) varieties all belonged to *Avena sterilis*.

Gram varieties were first tested for resistance to wilt *Fusarium orthoceras* App. et Wr. var. *Ciceri* Padwick) three years ago. The varieties I. P. 26, I. P. 9, and I. P. 29 have shown consistently heavy infection, and I. P. 28 appears to be moderately susceptible. A considerable number of varieties have taken only a small amount of infection, but unfortunately it cannot be assumed from this that they will prove satisfactory in the field. The question is complicated by other factors, one of which is the discovery of a foot-rot disease caused by a newly described fungus, *Operculella Padwickii* Kheswalla, which seems to attack all the varieties of gram which have so far been tested.

Out of the fourteen varieties and hybrids of pigeon-pea tested for resistance to wilt caused by *Fusarium udum* Butler, five showed less than five per cent infection and six showed over fifty per cent. Some of the resistant types were hybrids which show some promise of being useful commercially, whereas one of our difficulties in the past has been of poor quality.

Potatoes are being tested for their resistance to Early Blight caused by *Alternaria Solani* (Ell. et Ev.) J. et Gr. Tubers of a large number of varieties are being tested for their resistance to storage rots. This work is in a preliminary stage and it will be several years before results of practical value are obtainable.

Investigation of physiologic forms.—From the point of view of breeding disease-resistant varieties of crops, the discovery of a physiologic form against which a variety is not resistant amounts to the same thing as finding a new disease. Therefore physiologic forms must be studied in all plant-breeding work of this sort. It has been found that there is a second physiologic form of the loose smut organism of wheat, *Ustilago Tritici* (Pers.) Rostrup in India ; this form caused average infection percentages over two years of 3·7, 6·5, 7·9 and 5·4 respectively in four varieties of wheat which never showed any infection from the form collected in Pusa and used for testing purposes for four years.

Physiologic forms are also being looked for in *Colletotrichum falcatum* Went which causes red-rot of sugarcane. The cultures which have been isolated, fall into two groups, one light in colour and readily sporing, the other dark and sparsely sporing. These are the same two groups as were found in Louisiana by Abbott. The predominant race was the light-coloured one, which was also the case in the epidemic of P. O. J. 213 in Louisiana. The question of physiologic forms is also being followed up in the case of *Fusaria*, a start having been made with tests of *Fusarium udum*.

Methods of disease control.—The use of fungicides is being investigated, and it has been found that covered smut of barley can be controlled by sulphur dust in the eastern Punjab as effectively as it can be done in Egypt. The organic mercurial compound, Agrosan G. (ethylmercurichloride and tolymercuriacetate) has also been found effective.

The practicability of controlling smut (*Ustilago scitaminea*) and mosaic of sugarcane by roguing out infected clumps and proper seed selection has been proved. Over a 13-acre area badly smutted, which in certain plots had

over 40 per cent. infection, the amount of infection was brought down to one-fortieth of the original figures as a result of two seasons' roguing and selection, while by the third year the figure was negligible. In mosaic the results were obtained even more rapidly.

Factors influencing the development of disease.—One of the tests has been to find the sources and modes of infection of sugarcane with the red-rot fungus, *Colletotrichum falcatum*. Two facts of importance have been discovered. The first is that many of the canes examined in the epidemic areas have had the upper internodes infected while the lower ones appear healthy. This indicates that the infection came not through planting a diseased set but through entry of the fungus at a later stage in the growth of the cane, probably through the nodes. The second fact is that infection of healthy sets can be brought about by planting them in soil contaminated with debris from a diseased crop or with a pure culture of the fungus, resulting in the death of the shoots. It remains to be seen how long the fungus can survive in the soil.

Some valuable information has been secured on the factors influencing the development of gram wilt, *Fusarium orthoceras* var. *Ciceri*. It has been clearly shown that in Delhi and Karnal early sowing (in September) is to be avoided and that later sowing results in higher yields and less wilt. It has also been shown that the disease is complicated by drought in the sub-soil layer and that this aspect of the problem cannot be ignored in seeking control measures.

Spoilage of fruits and vegetables.—An assessment has been made of the spoilage of fruits and vegetables received in Delhi Market from season to season. It was found that there was a marked seasonal effect on the total amount of damage and also on the nature of the organisms concerned in rotting citrus fruits, apples, pears, and potatoes. To a large extent it was found that rotting in citrus fruits originated in some form of mechanical injury during picking, packing, or transport.

8. Insect Pests

Borer Pests of sugarcane.—The biology, the distribution and the seasonal occurrence of the caterpillar borers of sugarcane were studied at New Delhi, Karnal, Pusa, and Coimbatore, with field experiments conducted at Karnal, and Pusa. Canes Co. 331, Co. 285, and Co. 421 (arranged in descending order of merit) are more resistant to the top-borer (*Scirpophaga nivella*) than Co. 312, Co. 313, and Co. 210. The percentage of canes attacked by the top-borer has been considerably less in the resistant varieties. As regards the stem-borers and the root-borer, no differential attack has been observed in the varieties mentioned. From data collected from the experiments conducted at Karnal and Pusa, it was found that the total loss in tonnage by all the pests combined was slightly less in the resistant varieties, but the differences between the losses estimated for the different varieties were not significant. The loss in weight caused by the top-borer, the stem-borer and the termites was fairly high. In the case of the root-borer, however, this loss was low in most of the experiments.

Revised keys for the identification of the larvae and pupae of the borers were prepared by giving more minute details for more accurate identification in the field.

Field observations on the attack of sugarcane by the top-borer have shown that some varieties are more resistant than others, and that these resistant varieties have in common stronger and harder mid-ribs in their leaves, compared to those of the varieties that are badly attacked. It was observed in the field that the newly hatched out larva of the top-borer gets into the shoot by first biting into a mid-rib, a few inches above the base of an upper, almost fully unfurled, leaf and then tunnelling down the mid-rib to the base where the leaf is in contact with the shoot. The possibilities of utilising this information in the breeding of resistant canes has been under examination at the Sugarcane Breeding Station at Coimbatore. The results so far obtained show close correlation between the extent of lignification in the leaf mid-rib and the susceptibility of resistance to attack by the top-borer, and that the amount of lignification is inherited from certain of the parents. How far it would be possible to introduce into hybrids this desired anatomical character as a factor of resistance against the pest is under investigation.

Biological control of Sugarcane Borers and Pyrilla.—In recent years the study of parasites has assumed particular importance as it is now recognised by entomologists all over the world that the biological method of control of insect pests by parasites either alone or in conjunction with the mechanical or insecticidal methods is one of the important means of keeping some of the pests under effective check. The study therefore of the bionomics and biology of the parasites and predators of all the major pests of sugarcane received special attention at the Central Research Station at New Delhi and the substations. Several new parasites were reared in the entomological laboratories at New Delhi.

Possible or potential parasites of utility are (1) *Apentales flavipes* Cam. against stem-borer, (2) *Stenobrackon deesae* Cam. against top, stem or root-borer, (3) *Melcha ornatipennis* Cam. against top-borer, (4) *Brumus suturalis* Feb. predator against pyrilla eggs and sugarcane aphids.

Experiments on the effectiveness of *Trichogramma minutum* Riley in checking the stem and root borer population and thus reducing the percentage of attacked canes by these borers were conducted in Orissa and Bihar. The results of these experiments have not provided us with conclusive evidence in favour of *Trichogramma*. Nevertheless in all the experiments the percentage of canes attacked by stem and root borers at the time of harvest has been less and the yield per acre more in the case of *Trichogramma* colonised plots. The differences are significant in some years, while it is not so in others.

Studies on insect pests and their parasites in relation to changes in their environment.—The study of ecology of insects is an important basis in their control. Insects, although always present in varying numbers, increase under conditions favourable for their multiplication. By knowing the behaviour of a species in relation to its environment it is possible to foretell their increase or decrease. Even to utilize suitable enemies of pests it is necessary to determine conditions under which these can be artificially multiplied and liberated. Studies have been in progress under controlled conditions of variations in temperature and humidity, of the spotted bollworms of cotton belonging to the order Lepidoptera, which includes the largest number of agricultural pests. On the basis of laboratory work studies have been initiated on fluctuations in

the population of this pest in the field. The studies relative to the population of the spotted bollworms of cotton and their parasites have shown that rains in summer help in controlling the pest in two ways : firstly, by lowering the temperature which is beneficial to the parasite and thus increasing the natural parasitization of the bollworm, and secondly by raising the humidity which is directly injurious to the pest.

Field observations on the incidence of the pest and the parasite and their correlation with temperature and rainfall show general agreement with laboratory results. During the hottest and driest period of the year the population of bollworms is fairly high, while that of the parasite is extremely low. With the commencement of rains and consequent fall in temperature and rise in relative humidity the incidence of the parasite rises considerably and that of the host declines. This means that good and well spread rainy season keeps the parasite active and spotted bollworms do not assume serious status.

These observations open up a promising line of control work for the artificial mass multiplication of the parasite under conditions optimum for its development and its liberation in the field at the proper time.

Studies of immature stages of Indian insects and their mode of damage.—A vast majority of insects cause damage in their larval stage and that is the time for control measures. It is much easier to identify adults than their young ones as most of the descriptions available are those either of adult insects or of full-grown larvae which are of little value in actual practice, because by the time the larva is full-grown the damage caused to crops would be almost over.

Studies on the immature stages of several Indian insects have been continued and tentative means of identifying the various species, based on the structural characters as well as specific colour patterns with any other variations—colour or seasonal—have been arrived at.

There is evidence to show that larvae, especially those of Lepidoptera, readily react to slight changes in weather conditions, seasons and food, and show changes in their colour and other characters. This is especially true in the early part of their life. Sometimes the larvae in the same generation and frequently in different generations look so different that they can be mistaken as distinct species. Sometimes variations in colour patterns are of a definite character, specific to an insect species independent of any external or internal stimuli. It is also not rare to find species in which larvae so abruptly change their colour in the middle of their life, e.g., *Plusia* spp., *Heliothis* spp., *Laphygma exigua* Hubn., etc., that it is difficult to make out the identity of the individual species in the successive stages in their growth.

In order therefore to fully comprehend such variations, a close and detailed study of the colour variations in the larvae of several insects has been made. It has been found that for the food to have the fullest effect on the colour of the larvae they must feed on the same food plant from their very birth, otherwise intermediate shades will result. It was further found as in *Laphygma*

exigua Hubn., *Heliothis armigera* Hubn., etc., that the ground colour of the larvae though largely dependent upon the food, the colour patterns proper to the larvae were independent thereof.

During the course of a study of immature stages special attention was paid to discover new and alternative host plants of various insect pests. Alternative host plants can serve as trap crops, cultivated or wild, to attract the pests whereby valuable crops can escape serious pest infestations. Furthermore eradication of alternate hosts, if possible, can be used for starving the pest and thus keeping it under check. Illustrations of immature stages of insect pests were made with a view to describe colour variations under various conditions of food and temperature, and also various stages in their life-histories. The importance of such illustrations can be judged from the fact that over 2,000 of the colour plates were supplied on demand from various Departments of Agriculture, universities, etc. throughout India during this period.

Insect vectors of tobacco leaf-curl virus disease.—Tobacco which is prized for the quality of its leaf suffers from a disesase known as ' leaf-curl ' or ' crinkle ' and causes considerable loss to tobacco growers. This disease is most common in the Gangetic delta region, especially Bihar, where it sometimes assumes an epidemic form, when the percentage of plants infected may be as high as 60—70 or even more. The affected plants become stunted in growth, the stems being twisted ; leaves are reduced in size, curled, twisted, thickened and puckered ; while the flowers become dull reddish in colour. There are five types of leaf-curl designated as A, B, C, D and X according to their symptoms.

The white fly (*Bemisia tabaci* (Gennad.) = (*B. gossypiperda* M. & L.) has been established as the most important vector of the disease. Sunn-hemp (*Crotalaria juncea*) also suffers from a virulent type of leaf-curl, somewhat resembling that of tobacco, and is an important alternate host of the virus or viruses especially those causing A and X types of the disease of tobacco.

The weed *Ageratum conyzoides* has been found to be another important host from which the disease could be transmitted to tobacco and sunn-hemp and back from these to tobacco. The disease transmitted to tobacco from *Ageratum* was of D type. Similarly several weeds and cultivated plants proved to be alternate hosts of the tobacco leaf-curl viruses. There is at least one alternate host for each type of leaf-curl disesase of tobacco, and probably there are several hosts for each type.

The incidence of disease is directly proportional to the population of the white fly on the crop. Tobacco virus is not transmissible through the seed.

In view of the large variety of the host plants for the white fly and the virus, the control of the leaf-curl disease of tobacco by the eradication of its various alternate host plants is impracticable, if not impossible. The alternate methods are to evolve disease-resistant varieties or to check the white-fly vector by means of spraying at a suitable time of the season.

It would appear that if the seedlings both in the nursery and after transplanting are sprayed with fish oil rosin soap and nicotine sulphate, it would be effective in reducing the population of the vector and thereby decrease the disease.

Control of the Desert Locust in North-West India.—After the last locust cycle which lasted from 1926-31, the Imperial Council of Agricultural Research initiated a scheme of research and survey of the permanent breeding grounds of the Desert Locust. The scheme lasted for about 8 years during which extensive and valuable research in the laboratory and in the various desert tracts of North-West India was carried out by Khan Bahadur Afzal Hussain and by Rao Bahadur Y. Ramchandra Rao. Locusts mostly breed in spring in Baluchistan and in summer in Rajputana. There is eastward and westward migration in early summer and autumn respectively. Thus Baluchistan is an important source of locusts which breed in summer in Rajputana and from where they invade the Punjab and the United Provinces if they are in large numbers. In April 1939 the Government of India took over the intelligence and warning work in connection with the Desert Locust and established a permanent organization attached to the Institute. In the autumn of 1940 the locust assumed the gregarious phase and another cycle of locust menace began. The organization was expanded immediately to cope with the increased work. The staff carried out extensive surveys, issued warnings of the impending locust invasion, and acquainted the local officers of the concerned Provinces and States with the main features and life-history of the locust and suitable methods of its control. They were assisted in preparing scheme of anti-locust work. A series of classes were held at several places and demonstrations of control methods were given. The locust situation is kept under careful watch and the concerned Provincial and State authorities are being advised of their development, movement and control.

III. GENERAL ADMINISTRATION

Staff.—A list of the staff together with such changes as took place in various Sections is given in Appendix I (pp. 66).

Schemes of research financed by the Imperial Council of Agricultural Research.—Altogether nine Schemes financed by the Council were in operation during the year, four dealing with sugarcane research, one with tobacco breeding, one with potato breeding, one with wheat breeding, one with the breeding of crops for North-East India and one with development of some particular lines of research at the Institute. Besides, the work of testing Indian barleys for malting purposes was carried out for the United Provinces Department of Agriculture with the assistance of staff paid from the Council's grant. Necessary assistance in analytical work was also rendered to the Agricultural Marketing Adviser in connection with his Schemes on the grading of sugar and other products.

Training.—There were 80 candidates for admission to the post-graduate courses beginning in October, 1940, of whom 57 were recommended by the Provincial authorities. Twenty-one applicants were selected for admission, five in Botany, three in Agricultural Chemistry, five in Entomology, three in

Mycology, three in Agriculture and two in Sugarcane Breeding. Twelve students completed the course during the year and were awarded the Institute Diploma ; six in Botany, four in Agricultural Chemistry, one in Entomology and one in Mycology. The one-year course in Farm Organisation and General Farm Engineering was completed by three students. Besides the above, facilities were afforded to a number of short course students and honorary research workers as per details given in Appendix II (pp. 68).

A new advanced course in Animal Husbandry was inaugurated during the year with the object of providing selected students, who have potential capacity for livestock work, a further training in Cattle breeding and management. The training lasts for eight months, commencing in the middle of July each year and is given partly at this Institute and partly at the Imperial Veterinary Research Institute, Izatnagar. Thirteen students took advantage of this course during the year.

As usual, students from the Imperial Dairy Institute, Bangalore, were afforded facilities to study the methods of cattle breeding and mixed farming at the Institute and its Substation at Karnal.

Library.—The total number of publications received in the Library both by way of exchange and by purchase amounted to 2,016. Over 4,500 books were issued out on loan, of which 700 were sent out to scientific workers in Provinces.

IV. ACCOUNTS

The total expenditure of the Institute and its Substations at Karnal and Coimbatore during the financial year ended March, 1941, amounted to Rs. 7,94,744.

Name of Establishment	Expenditure Rs.
General expenditure of the Institute, including the office of the Director, Irrigation, Power supply, Gas Plant and the Estate Establishment	2,12,700
Agriculture Section	1,10,910
Botany Section	49,034
Chemistry Section	66,891
Entomology Section	68,858
Mycology Section	44,802
Locust Warning Organisation	56,985
Agricultural Substation, Karnal	95,577*
Surgarcane Station, Coimbatore	88,987
	7,94,744

**Vide* the audited Income and Expenditure account reproduced on page 31.

The expenditure of the various Research Schemes financed by the Imperial Council of Agricultural Research, amounted to Rs. 1,73,113, as shown below which was met from the funds provided by the Imperial Council of Agricultural Research.

	Rs.	Rs.
(*a*) Development of Research		22,162
(*b*) Research on Diseases of Sugarcane		18,889
(*c*) Research on Insect Pests of Sugarcane		46,084
(*d*) Research on Chemistry of Sugarcane		2,801
(*e*) Research on Genetics of Sugarcane		3,435
(*f*) Sugarcane Substation, Karnal		11,853
(*g*) Tobacco Breeding Substation, Guntur		15,663
(*h*) Potato and Wheat Breeding Substation, Simla :—		
Potato Breeding	21,588	
Wheat Breeding	6,286	27,874
(*i*) Botanical Substation, Pusa		24,352
		1,73,113

The receipts of the Institute and its Substations amounted to :—

	Rs.
Main Institute	42,076
Agricultural Substation, Karnal	63,481*
Sugarcane Station, Coimbatore	9,719

**Vide* the audited Income and Expenditure account reproduced on page 31.

Income and expenditure account for the year ending 31st March 1941—Agricultural, Substation, Karnal.

Income. Particulars.	1939-40.	1940-41.	Expenditure. Particulars.	1939-40.	1940-41.
	Rs.	Rs.		Rs.	Rs.
1. By sale of Dairy produce, etc. . .	12,926	11,946	1. Pay of officers and establishment .	22,831	32,166
2. By sale of Farm produce, etc. . .	39,942	50,130	2. Travelling allowances . . .	198	521
3. Miscellaneous receipts . . .	619	1,405	3. Feed of dairy cattle, etc. . .	3,165	7,299
Deficiency . .	9,711	32,096	4. Production of grain and fodder, etc..	21,188	27,783
			5. Ice, salt, acid, etc. . . .	32	199
			6. Medical stores	689	425
			7. Workshop	1,852	2,000
			8. Fuel, light, water, etc. . . .	2,845	3,400
			9. Service stamps, etc. . . .	306	400
			10. Freight on stores	183	194
			11. Miscellaneous contingencies . .	1,491	1,400
			12. Capital expenditure . . .	2,034	698
			13. Repairs to plant and machinery .	2,768	1,991
			14. Petty construction and repairs .	3,616	3,382
			15. Steam tackle grant . . .	..	13,719
Total . .	63,198	95,577	Total .	63,198	95,577

REPORT OF THE IMPERIAL AGRICULTURIST

(C. H. Parr)

I. INTRODUCTORY

I took over charge of the office of the Imperial Agriculturist on 24th August, 1940. The programme laid down previously for the working of the two farms at Delhi and Karnal was carried out. Some new items of work were introduced. These were :—

(1) Dry farming after a preliminary inundation.

(2) Preservation of various green fodders, including legumes, as silage.

(3) Study of fodder crops and method of curing them for hay.

(4) Development of grass area for pasturage.

(5) Manuring of crops for higher production.

(6) Feeding of cows for higher milk production.

II. AGRICULTURAL SECTION, NEW DELHI

1. Season

The total rainfall during the year from June, 1940 to May, 1941 amounted to 22·95 inches, as compared with 20·20 inches in the previous year.

The grasses mentioned in the last year's report remained under trial.

2. Sugarcane Varietal Work

Eleven new varieties, Co. 460, 461, 462, 463, 464, 465, 550, 551, 552, 553 and 554, were received from the Sugarcane Expert, Coimbatore, in March 1940 and were planted in short rows. Out of these, Co. 462 made healthy vigorous growth with good tillering, but was found to be poor in sucrose content. Co. 461, 463, 464 and 554, showed fair growth.

3. Manuring

Owing to the high cost of water for irrigation, sound farming demands high yields. The soil at Delhi stands in need of systematic manuring, and the question is receiving attention in two directions (1) in methods of storing farmyard manure, and (2) in developing the technique of green-manuring.

With regard to (1), to the question of the production of good farmyard manure is added that of fly breeding prevention to comply with the bye-laws of the New Delhi Municipal Committee. Experiments in regard to farmyard manure storing were, therefore, continued in collaboration with the Imperial Entomologist.

4. Preservation of fodder

Silage.—Different opinions are held as to the advisability of chopping the silage crop. A comparison was made between chopped and unchopped sorghum in making silage. Chemical analyses of the resulting silage showed that

there was not much difference in the composition of the samples collected from top, middle and bottom of the same pit. The top silage showed less acidity development than the other two portions in both the chopped and unchopped crop. The chopped silage, however, had considerably higher acidity, but was lower in total food units and albuminoid ratio. Both kinds of silage were relished by cattle. The long silage was chopped before feeding. The possibility of making silage of leguminous crops with the aid of molasses was also investigated.

Hay.—Experiments were carried out on different methods of making hay from berseem, lucerne and other legumes such as (1) drying on the ground, (2) drying in the shade of a verandah and (3) tying the green crops into small sheaves and drying them by hanging on fencing wires. The last method proved the most successful and resulted in the production of a hay of high quality.

5. Seed supply

The quantities of seeds distributed from Delhi and Karnal are shown below :—

Crops	Quantity in lb.		Crops	Quantity in lb.	
	Delhi	Karnal		Delhi	Karnal
Anjan grass (seed) (*Pennisetum cenchroides*)	0·51	..	Sannhemp	4·11	..
Barley	164·56	..	*Senji* (*Melilotus parviflora*)	12·34	..
Berseem	29·83	1,071·77	Soybean	540·22	640·80
Cowpeas	205·70	543·09	Sudan grass (seed)	0·51	..
Elephant grass (cuttings)	20·57	..	Sugarcane (setts)	329·12	..
Gram	205·70	73,064·69	Wheat	164·56	35,711·20
Linseed	0·51	246·86	Peas	292·61	975·09
Maize	5·14	..	Paddy	..	1,419·30
Oats	5,986·38	6,327·33	Lentil	..	164·60
Pigeon peas	0·51	..	Flax	..	45·39

6. Research and Experiments

Manurial trial with berseem.—An experiment was arranged to examine the differential response of different manures on the yield of green fodder and seed.

The best method of sowing berseem.—A preliminary experiment was taken up with four methods of sowing as detailed below, to see whether the usual method adopted on this farm could be improved upon :—

A. Irrigating and broadcasting soaked seed (standard method of the farm).

B. Irrigating, planking and broadcasting soaked seed.

C. Irrigating lightly, broadcasting soaked seed and then planking lightly.

D. Broadcasting soaked seed, raking and finally irrigating.

Though the differences in yield were not statistically significant, the treatments B, C and D showed improvements over A.

Berseem seed rate experiment.—The experiment was conducted in randomized blocks which showed that the differences in yield with seed rates of $7\frac{1}{2}$, 10, $12\frac{1}{2}$ and 15 seers per acre were not significant.

Time of sowing berseem in relation to seed production.—This experiment showed that the best yield was from a crop sown on October 15, the other dates in the order of merit were October 1, November 1, December 1, December 15 and November 15.

Alternative cold weather fodder crops experiment.—In continuation of the last year's experiment, maize was grown in the *kharif* of 1941 to study the residual effect of the various fodders grown in the previous *rabi* season. The yield of green maize after a short crop of berseem was higher than that after the long crop of berseem, and the presumption on which the treatment B (berseem cut up to the end of March) was introduced last year has been substantiated to some extent.

Varietal yield trials.—Eight strains of cowpeas suitable for this tract were selected for yield trials which were carried out at Delhi and Karnal. Yield trials with wheat and gram were continued at Delhi on previous lines, except that Cawnpore 13 was added to wheat varieties.

Residual effect of manures.—In this experiment, manures were applied in the *kharif* 1939, and maize was grown in the same season to see the differential response of the various treatments. In the following *rabi*, barley was grown without any manurial treatment. The results obtained from these two crops were given in the last report. During the year under review, maize was again grown in the *kharif* season to see whether any residual effect was still evident. The yield of maize showed that with the exception of treatment K (farmyard manure at 120 lb. N) the yields under all other treatments were very similar.

Green manuring experiment.—At Karnal, the effect of green manuring with sorghum and cowpeas, with and without fertilizers to act as starters for decomposition, on the yield of wheat I. P. 165 was examined. The results were in favour of cowpeas in combination with Niciphos II. At Delhi, sorghum was brought from outside and buried at the rate of 200 maunds per acre. In this experiment quicker rotting was observed in the treatment with dung and bone meal, followed by dung, cattle urine, sorghum alone and sewage water in the order mentioned.

Dry farming experiments.—In canal irrigated tracts, there is heavy demand on canals during the whole of the *rabi* season, and the area under *rabi* crops is to a great extent limited by the supplies of water available at this time of the year. Most of the rivers in Northern India, on the other hand, usually carry much surplus water uselessly to the sea during the late monsoons. It seems possible that this surplus water may be put to use by giving land heavy irrigations in August and September, and by retaining by proper conservation methods this moisture in the soil for *rabi* crop production. The moisture so conserved supplemented by winter rains will in average years provide for fair *rabi* crop production. If suitable methods of moisture conservation can be evolved, it

would appear that large uncropped areas could thus be brought under gram, wheat and barley.

Preliminary experiments were laid down at Delhi and Karnal to test out these possibilities. Wheat and gram were tried under three different seed rates and at three different spacings. At Delhi, the wheat crop failed due to the lightness and porosity of the soil, as well as due to the incidence of white ants. The gram crop experiment was vitiated somewhat by a very short visit of locusts. At Karnal, some plots in the gram experiment were damaged by cut-worms. The different spacings and seed rates did not show any significant differences, but the series irrigated lightly and heavily gave higher yields than the no irrigation series.

Village plot experiment.—The village plot experiment (Cultivators' holding) mentioned in the last year's report was continued. The scheme of this experiment has now been reorganised and the site changed.

Determination of the best time for sowing gram.—The experiment was conducted on the same lines as reported in the two previous years. The late sown plots again yielded better results than the early sown plots.

Effect of ploughing with Victory plough (inversion) and country plough (non-inversion) on the yield of oats I. P. 1.—The experiment was repeated on the same lines as reported last year. The mean difference in favour of Victory plough was 1·32 maunds per acre which, however, is not statistically significant.

7. Cattle Breeding

The work with the Pusa pedigree Sahiwal herd was continued on the lines so ably developed by Mr. Wynne Sayer, the achievement of whose methods have shown (*i*) the possibilities latent in Indian breeds of cattle and (*ii*) the means whereby these possibilities can be developed and turned to account.

These methods incorporated in the general policy of management laid down in 1932, with regard to (1) four times milking, (2) early maturity, (3) pre-calving milking, (4) handling of the animals and (5) special feeding of calves, have been closely followed during the year.

At the end of the year, the herd consisted of 12 breeding bulls, 76 milch cows, 49 young male stock and 70 young female stock—a total of 207 head.

A high standard of health, milk production and breeding capacity was maintained in the whole herd. The general trend was towards further improvement, and no signs of deterioration in constitution or production as a result of the methods applied were apparent. As evidence of this fact, it may be mentioned that in the usual lactation period of 306 days, three cows yielded more than 10,000 lb. of milk, three more than 9,000, three more than 8,000, five more than 7,000 lb. of milk. Calving at ages between 2 years and 2 years and 5 months, one heifer Lakhsur gave 9,308 lb., another 8,947 lb. and three more produced more than 7,000 lb. of milk in the same period of 306 days which is pretty good evidence, that, in the young stock there is an increasing capacity for milk production founded on a constitutional development capable of bearing this high functional strain.

Number of animals in various categories since 1932

Year	11,000 lb.	10,000 lb.	9,000 lb.	8,000 lb.	7,000 lb.	6,000 lb.	5,000 lb.	4,000 lb.	3,000 lb.	Between 3,000 and 11,000 lb.
1932 . . .				1		3	11	4	11	130
1933 . . .				2	8	9	6	6	12	143
1934 . . .				6	5	11	9	6	10	47
1935 . . .			1	6	4	5	11	7	5	39
1936 . . .			4	1	6	6	9	6	5	37
1937 . . .	1	1	3	2	1	4	9	14	7	42
1938 . . .		2	4	4	6	13	6	10	9	54
1939 . . .	1	1	1	4	6	6	10	13	6	48
1940 . . .		3	5	3	8	16	12	3	6	56

Compared with last year, the monthly average yield was 33,499 lb. against 31,751 lb., the daily average yield was 1,097 lb. against 1,042 lb., and the percentage of cows in milk was 70·2 against 67·8 of the previous year. The average yield of second calvers was 25·4 lb. and of heifers 17·9 lb. as against 20·0 lb. and 20·6 lb. of the previous year.

Calf-rearing.—There were 67 births, of which nine died. One succumbed to foot-and-mouth, four to coccidiosis and the remaining four to common ailments.

Total proceeds from the sale of dairy produce and cattle was Rs. 28,140 against Rs. 26,349 of the previous year.

III. AGRICULTURAL SUBSTATION, KARNAL

1. Introduction

In addition to the normal experimental work in agriculture, large scale farming, power farming and cattle breeding, the substation serves as a training centre for the students taking advanced courses in Agricultural studies. Students taking the Advanced Animal Husbandry Course, the Post Graduate Course of the Imperial Dairy Institute, Bangalore, the Indian Dairy Diploma Course, the Post Graduate Course of the Imperial Agricultural Research Institute, New Delhi, were catered for, and training was also given to a number of Short Course students.

2. Season

The total rainfall during the year from July 1940 to June 1941 amounted to 17·97 inches as compared with 13·91 inches in the previous year.

3. Cropping plan

Some change was made in the cropping plan of the substation beginning from the *rabi* 1941. The whole area under direct cultivation was divided into the following units :—

(*i*) Dry Farming ;

(*ii*) Mixed Farming ;

(*iii*) Seed Multiplication block ; and

(*iv*) Reclamation of *Usar* land.

4. Manuring

The following methods of manuring were adopted :—

(*a*) By large scale compost making—about 22,269 maunds of compost manure was made at a cost of 3·5 pies per maund.

(*b*) By carting dung and litter direct to the fields and ploughing it in. This is less costly, but takes a longer time to decompose.

(*c*) By green manuring with sannhemp—under existing practices success of this method depends on rainfall and the availability of irrigation water to effect complete rotting before the next crop is sown.

(*d*) By growing legumes in rotation with other crops. This method has a great restorative effect on the soil.

5. Machinery and Implements

After determining the actual draw-bar-pull of the tractors by means of a dynamometer, it was found that the implements used were below the normal load of the tractors. A tillage-combine was, therefore, designed and parts were assembled in the farm workshop. With some more improvements the implement will, by its increased output of work, lead to a reduction in the cost of tillage. Two Olpad threshers and one peg roller were manufactured in the farm workshop.

6. Cattle breeding

At the close of the year the pedigree Tharparkar herd consisted of 11 stud bulls, 89 milch cows, 88 young female stock and 47 young male stock—a total of 235 head.

The average milk yield per cow per day was 19·5 lb. against 19·6 lb. of the last year.

Early maturity.—The early maturity experiment coupled with four times milking, pre-milking and pre-handling was continued.

Calf-rearing.—There were 79 births during the year out of which 70 calves were reared. Two calves died of common ailments and seven of infectious diseases.

IV. PROGRAMME OF WORK FOR 1941-42

(Delhi and Karnal)

1. Mixed farming including the study of crop rotations for building up soil fertility.

2. Dry farming methods after a preliminary inundation in September.

3. Preservation of soil moisture by mulching with waste materials of the farm and appropriate cultural methods.

4. Preservation of the various green fodders as silage.

5. Study of fodder crops and methods of curing them for hay.

6. Development of grass areas for pasturage.

7. Manuring of crops for higher production.

8. Conduct of field experiments for testing the effect of manures, fertilizers, cultural methods and irrigation on different crops.

9. Dynamometer investigations on the resistance of soil to the various bullock drawn implements.

10. Testing of agricultural implements and machinery.

11. Conduct of experiments for other Sections of the Institute.

12. Continuation of cattle breeding operations on the pedigree Sahiwal and Tharparkar herds with special reference to transmission of milch characters.

13. Special feeding of the young stock with a view to early maturity in the Sahiwal and Tharparkar herds.

14. Feeding of cows for higher milk production.

15. Training of post-graduate students.

V. STATISTICAL BRANCH

(P. V. Krishna Iyer)

Distribution of yields of wheat for different plot sizes from different areas

In my report for 1938-39, some discussion regarding the distribution of plot yields has been made on the basis of investigations on the uniformity trial data collected at Karnal with wheat I. P. 114. In continuation of this, further work was done on this aspect.

Sampling

The errors of three different methods of sampling were investigated using the wheat uniformity trial data.

(*a*) Samples of size $5' \times 5'$ were taken at random after dividing the whole area into four equal parts. (*b*) Composite samples of five $5' \times 5'$ units were formed by taking the units at random from each of the four portions. (*c*) Samples of size 125 sq. ft. were taken at random from each of the four portions. For each method of sampling, 25 samples were formed by taking separately 1, 2 and 5 per cent units of the whole area. The conclusions are :—

(*a*) The standard deviation of the second method of sampling was considerably less than that of the other two methods.

(*b*) Variance of the mean and the variance of the standard deviation were least when the percentage sampled was 5 per cent of the total area and increased in ascending order of magnitude as the percentage area sampled diminished. Further work is in progress.

Influence of irrigation on the water-table of wells

To examine the influence of irrigation as practised at the Institute on the rise or fall of the water-table of wells, the depth of water level from the ground of wells situated in the Institute area is recorded on the 1st and the 16th of every month and was started from 1st October, 1939. A preliminary investigation on the data collected during the period October, 1939 to October, 1940, was carried out and irrigation as practised in the Institute did not appear to raise or lower significantly the water level of wells.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(B. P. Pal)

I. BREEDING FOR DISEASE RESISTANCE AND OTHER CHARACTERS

Wheat (*Triticum vulgare* Host)

Rust resistance.—Breeding for resistance to the black, brown and yellow rusts was continued at the Substation at Simla. The F_6 generations of nine crosses between resistant foreign varieties and improved Indian varieties, and several new crosses including some between Indian wheats and a *vulgare* variety from Kenya which has been found to be highly resistant to the Indian races of black rust, were grown.

Smut resistance.—Collaborate experiments with the Section of Mycology and Plant Pathology to test the resistance of a large number of wheat varieties to loose smut and flag smut were continued. The results have shown that a few varieties are immune, a large number are highly resistant, while the majority are susceptible.

Drought resistance.—The trial, under dry conditions, of two hundred and sixty varieties was repeated ; thirteen varieties gave very satisfactory yields under these conditions.

Pigeon-Pea (*Cajanus Cajan* (L.) Millsp.)

Wilt resistance.—One hundred and twenty cultures, in the F_5 generation, selected for their wilt resistance were grown in a field heavily infested with *Fusarium* wilt at Pusa ; the same cultures were also grown at Delhi where however wilt was practically absent. Suitable selections were made from them.

A number of pigeon-pea varieties and new hybrids have been tested for wilt resistance under controlled conditions of artificial infection, by the Imperial Mycologist, and while the so-called resistant selection from I. P. 69 pigeon-pea did not show any resistance under these severe conditions, some of the hybrids gave very encouraging results.

Linseed (*Linum usitatissimum* L.)

Rust resistance.—All except two hybrids out of a large number of cultures in the F_7 generation grown both at Delhi and Karnal remained completely rust-free, whereas such of the parent varieties as were known from previous experience to be rust-susceptible showed varying degrees of infection.

Potato (*Solanum tuberosum* L. and *Solanum* spp.)

Disease resistance.—The breeding of potato varieties resistant to Early Blight, Late Blight and virus diseases was continued at the Substation at Simla, with the collaboration of the Imperial Mycologist. Early Blight tests carried out by him indicated that some of the species and hybrids possess a promising degree of resistance. With regard to the Late Blight problem, 621

plants from four different crosses involving *S. demissum* were raised and 176 plants were retained for further work. The maximum yield obtained was over four pounds to a plant.

The grafting experiments with four important virus diseases were continued. *S. Rybinii*, which is said to be resistant to viruses, showed necrotic infection of the streak type. Seedlings of four crosses between this species and *S. tuberosum* were also found to be susceptible.

Fourteen inter-varietal hybrids which had given very promising results at Simla during the past two years or so were sent out to hill stations in the provinces and states for preliminary trial.

Tobacco (*Nicotiana Tabacum* L. and *N. rustica* L.)

Virginian tobacco.—Further progress was made with varietal, rotational and manurial trials at the Tobacco Research Substation. The former have shown that, besides *Bonanza* and *Gold Dollar* mentioned in last year's annual report two other imported varieties, *Amarelo* and *Yellow Pryor*, deserve trial as promising cigarette varieties for Indian conditions. Comparison of freshly imported seed of the well-known variety Harrison's Special with seed acclimatised in India for one or more years indicated that there is no real ground for the belief that cigarette varieties deteriorate in India because of climatic reasons.

At Pusa, crosses between *Bonanza*, *Gold Dollar*, *Harrison's Special* and some of the Imperial Pusa strains were under study.

II. GENETICAL AND CYTOLOGICAL STUDIES

Cytogenetical studies in the oleiferous Brassicae

The studies in connection with the cytotaxonomic classification of the cultivated *Brassicae* were continued. Cytogenetic work on the interspecific and intergeneric crosses was also in progress.

Studies in Polyploidy

Colchicine-induced polyploids

Gram.—The C_3 generation of tetraploids was studied with regard to their pollen fertility and morphological characters. The $4n$ number of chromosomes in several plants was confirmed.

Chillies.—The large number of tetraploids, mutants and " interchange " plants obtained from colchicine treatment were under study in the third generation. To assess the effect of continued natural selection on these tetraploids in different environments, a few of them were grown in Simla, Pusa and Guntur together with controls. The tetraploids maintained their gigas characters but showed a greater variability in quantitative characters compared to the diploid. The tetraploids will now be grown successively for a number of years in the three places for a study of the ultimate types that may be evolved.

The progeny of the interchange heterozygotes were examined for pollen sterility and found to give a 1 : 1 segregation of pollen-fertile and semi-sterile plants as would be expected.

Tobacco.—Experiments to induce chromosome doubling in the sterile interspecific hybrid, viz. *Nicotiana glauca* ($2n=24$)$\times$*N. plumbaginifolia* ($2n=20$), were continued and colchicine was applied to growing vegetative buds on grafted plants, in various media and in various ways.

Previous attempts to induce seed-setting on this totally sterile hybrid by back-crossing it with its parents and other *Nicotiana* species did not meet with success. The back-crosses were again repeated this year on a large scale and it was gratifying to note that six capsules with seeds developed when the hybrid was crossed with *N. glauca*, one of its parents ; crosses with other species did not give any ripe capsules.

Spontaneously-occurring polyploids

The following spontaneously-occurring polyploids were observed and studied :

Chillies.—In one of the bulk cultures of I. P. 51 one triploid plant was isolated for the first time as a naturally-occurring polyploid. It was highly sterile and had $2n=36$ chromosomes. The chromosomes formed varying numbers of trivalents and univalents at meiosis.

Brassica.—An interesting spontaneously-occurring haploid plant was discovered in a *toria* (*B. campestris*) culture. The plant was the first of its kind and was a reduced replica of the diploid ; it was dwarfish with small leaves and flowers.

A number of tetraploid plants of *B. campestris* were obtained as the progeny of an interesting chimaeral plant discovered during 1939-40. This plant had a few branches with normal pods and seeds and a few others with pods that looked normal but contained practically no seed except one or two in some. Seeds from the fertile pods and the few from the sterile ones were collected and sown separately during 1940-41 and it was found that plants obtained from the seeds of the sterile pods were all tetraploids, while those from the seeds of normal pods were diploids.

Pigeon-pea.—A few plants raised from the seeds set on the tetraploid plant discovered during the previous year were studied with regard to the morphological characters. Flower buds were fixed for examination of their chromosome numbers.

Other genetical and cytological studies were on intergeneric and interspecific hybrids in *Triticum* and in other crop plants with a view to obtaining knowledge regarding their usefulness for breeding purposes.

Hybrid vigour.—Heterosis was again investigated in tobacco (*N. Tabacum*), the characters under observation being height of plant, size and number of leaves, time of flowering and yield of leaf. The general growth of the crop this year was not good, that at Delhi being affected by mosaic and later on by frost, and that at Pusa by leaf-curl disease. However some of the crosses showed conspicuous hybrid vigour ; in one cross a distinct difference in vigour between the reciprocals was observed.

Clear hybrid vigour was also observed in the egg-plant (*Solanum Melongena* L.) and in chilli (*Capsicum annuum* L.) The latter however was badly damaged by white ants, and as in the previous year, the experiment on this

plant had to be abandoned. Preliminary observations on heterosis were commenced in the bitter gourd (*Momordica Charantia* L.).

III. VERNALIZATION AND PHOTOPERIODISM STUDIES

In gram, experiments were designed to investigate the effect of (*a*) " devernalization ", (*b*) daily variation of temperature, that is, subjecting the seeds to two different temperatures within twenty-four hours, (*c*) vernalization of seedlings at different stages of growth and (*d*) of seeds at different stages of germination. Attempts to vernalize the seeds during the stage of ripening and to dry vernalized seeds without loss of viability or the effect of the treatment were also continued. With wheat, there was no pronounced earliness in any of the five varieties tested under field conditions ; two of these were English wheats and the other three Indian. Results of light experiments in gram and wheat confirmed those obtained last year.

Vernalized seeds of *Sorghum* were sent for sowing at the Dry Farming Research Station, Sholapur, at the request of Mr. N. V. Kanitkar. The results however were reported to be not promising.

The study of the effect of short day conditions (9 hours daylight) on fourteen species of potatoes was continued at Simla and the results confirm last year's observation that short day conditions exercise a general depressing effect on flowering and bring about a marked decrease in the growth period. With the exception of *S. tuberosum*, *S. andigenum*, *S. leptostigma* and *S. Rybinii*, all the species tested gave higher yields under short day conditions.

IV. STUDIES IN VARIABILITY OF CROP PLANTS

Wheat.—The ear and grain characters of wheats obtained from the different provinces of India comprising 1,173 samples were described according to the standard schedules drawn up by the committee on variability in wheat which was set up by the Imperial Council of Agricultural Research (*Indian J. Agric. Sci.* 11: 479-92).

Potatoes.—The study of the collection of 118 samples of commercial varieties sent by the Agricultural Marketing Adviser to the Government of India was completed and a report sent to him for incorporation in the report on the marketing of potatoes.

The study of new material received from the Empire Expedition to South America was continued.

Other crops.—Varietal studies of the other crops mentioned in the last year's annual report were continued.

V. MISCELLANEOUS INVESTIGATIONS

Seed-setting in berseem (*Trifolium* spp.).—During the year under report, five varieties of berseem obtained from different places were under trial for study of seed-setting under Delhi and Pusa conditions.

Potato storage.—Small-scale experiments indicated that storing in pits was not successful under Delhi conditions, and that storing tubers under sand

was better than storing without sand. The most interesting result was that small-sized tubers kept distinctly better in storage than large-sized ones. This is being followed up.

Rest period of potato tubers.—Experiments in which smoke was used to break the rest period of tubers showed that while the rest period can be broken by this means the percentage of success was too low to permit of its successful exploitation.

Tobacco leaf-curl disease.—Work is now limited to observations on the incidence of disease in the various varieties grown. Leaf-curl attack was severe during the year under report and *Harrison's Special*, as in previous years, was found to be specially susceptible.

Gram wilt.—The experiment mentioned in last year's report to study the effect of growing *Sorghum* before sowing gram, on the incidence of wilt, was continued in a modified form. Besides the comparison of *Sorghum* versus fallow, two other comparisons, viz., early versus late sowing, and farm yard manure versus no manure were introduced. The only " treatment " which appreciably lessened the incidence of wilt was late sowing.

Yield trials.—Varietal trials with wheat, barley, oats, rice, etc., were carried out at Pusa and the results are given in the report of the Botanical Substation.

Cooking tests.—A further series of cooking tests with potatoes was conducted. In general, the results were in agreement with those of previous tests.

VI. CROP OUTTURNS AND SEED DISTRIBUTION

The crop outturns were again very satisfactory.

Seeds were supplied by the Section and the Botanical Substation, Pusa, to the Agricultural Section for multiplication and also to a large number of agricultural officers and private individuals in India and abroad.

VII. PROGRAMME OF WORK FOR 1941-42

The major items are :—

(1) Continuation of the breeding of disease-resistant and drought-resistant crops.

(2) Continuation of the genetical and cytological studies mentioned in this report.

(3) Continuation of the special studies on vernalization and hybrid vigour.

(4) Continuation of varietal studies and maintenance of crop collections.

(5) Investigation of the factors influencing seed-setting in berseem.

REPORT OF THE SUGARCANE EXPERT

(T. S. VENKATRAMAN)

I. INTRODUCTION

This report embodies work on sugarcane as carried on at the Coimbatore Sugarcane Breeding Station under the control of the Imperial Agricultural Research Institute, New Delhi and two Schemes financed by the Imperial Council of Agricultural Research, viz., (1) Scheme for Research on the Genetics of Sugarcane, Coimbatore and (2) Sugarcane Sub-station, Karnal.

II. SUGARCANE BREEDING

Parents.—Besides the inter-generic Sugarcane × *Sorghum* hybrids that have been used as parents for the last three years, another suitable parent for introducing early and good juice quality was secured in a hybrid between the sugarcane P. O. J. 2725 and a troublesome weed (*Imperata*) from the Malay States.

In the breeding of tropical types Co. 440 was extensively used for introducing both earliness and juice quality in the hybrids. The Sugarcane-Sorghum hybrid Co. 356, which is getting to be popular in parts of Bihar and elsewhere, was also employed as parent. The cane Badila (known as Fiji B in the Madras Presidency) does not usually arrow at Coimbatore. Reports were received about its flowering in certain of the experimental stations in the West Coast and seeds were duly collected. This is expected to be a desirable parent for introducing both good habit and high juice quality.

Breeding for resistance.—Marked attention was paid to the study and inheritance of anatomical characters likely to be useful in the resistance of cane varieties to certain pests and diseases. Study of *Saccharum spontaneum* hybrids has been of particular use and interest from this view point and certain parents have been found to transmit desirable characters to their progeny.

III. INVESTIGATIONS

Chromosome doubling.—Cyto-genetic investigations* have indicated that the phenomenon of doubling of chromosomes in sugarcanes when hybridized with certain other sugarcanes, species and genera is probably responsible for (1) the comparatively rapid economic results from cane breeding and (2) the fertility of F_1 hybrids even when the parents are widely separated from each other taxonomically. The very wide variations noticed even in populations from selfed parents would appear to be traceable to (1) the very large number of chromosomes and (2) the parents being both complex hybrids and polyploids.

Sterility.—Besides treatment with well known substances, like Colchicine, an attempt was made to overcome sterility by hybridizing the infertile plants with other closely related hybrids. The hybrids between Vellai and *Saccharum narenga* are sterile but when crossed with a hybrid between Vellai

*The Scheme is financed by the Imperial Council of Agricultural Research.

and *Saccharum spontaneum*, they gave a fair number of seedlings. Certain of the Bamboo hybrids are showing marked abnormalities in first nuclear division with a large number of univalents.

Artificial control of time of flowering.—Experiments for controlling time of flowering in canes have been in progress for some time. Results from photoperiodism experiments enabled the pollination of the mother parent P. O. J. 2725 for a month and a half against the usual period of about three weeks. This was secured by additional artificial illumination with sixty watt lamps. About a dozen crosses not previously possible with P. O. J. 2725 as mother were also successfully effected during the year.

Pollen preservation.—Pollen preservation experiments were continued and it was possible to extend the period of preservation to 45 days with canes like *Saccharum spontaneum* and Kansar, but they steadily lost in viability after about 26 days. Pollen of over twenty varieties were under study and showed striking differences in this respect.

IV. SUGARCANE SUB-STATION, KARNAL*

Hybrids between Co. 385 × Co. 331 and Co. 421 × Co. 312 proved unsatisfactory ; the former because of thin canes and poor tillering and the latter because of bad habit. Certain of the Karnal selections—CoKs. 26, 30 and 31—are under trial in the substropical sugarcane testing stations. Experiments first initiated at the Sub-station enabled the obtainment of healthy material even from smutted clumps and this should prove of particular use to breeders.

V. DESPATCH OF CANES

As canes.—Eight seedlings were raised to the status of ' Cos. ' during the year. These, along with three seedlings imported from Florida and three fodder types, were distributed to the various testing stations in India during the year.

As fluff.—A dozen packets of sugarcane seeds in the form of fluff were sent to Shahjahanpur in the United Provinces, and Risalewala and Lyallpur in the Punjab, either for raising seedlings or for other experiments.

VI. PARENTAGE OF NEW ' CO.' SEEDLINGS

The parentages of new ' Co.' seedlings distributed during the year are given below :—

Co. 466—Co. 419 × Co. 408♂

Co. 467—Co. 421 × Co. 331♂

Co. 468—Co. 331 × S. W. 111♂

Co. 469—P. O. J. 2878 × B. 3412♂

Co. 555—Co. 421 × Co. 357♂

Co. 556—Co. 213 × (P. O. J. 2878 × Co. 331)♂

Co. 557—Co. 508 × Co. 313♂

Co. 558—Co. 300 × Co. 546♂

Co. 559, Co. 560, Co. 561 } (Vellai × Sorghum halepense) × Sorghum halepense ♂

*This Sub-station at Karnal is financed by the Imperial Council of Agricultural Research.

VII. PROGRAMME OF WORK

The breeding work will be continued with particular emphasis on specialised lines such as ' early ' and ' late ' ripening and resistance to adverse conditions including pests and diseases.

Cyto-genetic work on parents and ' Co.' canes will be continued to further elucidate inheritance of characters and try and build up genetically purer parents for introducing greater certainty into breeding operation.

Investigations on pollen preservation, controlling time of flowering of parents, methods for overcoming sterility in canes and the artificial production of polyploids will be continued. Attempts will be made to improve micro technique with the object of securing more reliable chromosome counts in sugarcane material.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(B. Viswa Nath)

Mr. Jatindra Nath Mukerji, Assistant Agricultural Chemist, retired from service during the year on superannuation. Mr. Mukerji was associated with this Section from its inception and did considerable pioneering work in the soil and agricultural chemistry problems of the country. In his retirement the Section loses an officer with experience and knowledge.

An additional feature of the year was the equipment for and beginning of spectroscopic and micro-chemical analysis. New lines of collaborative research with the other Sections of the Institute were initiated.

Analytical control of grade standards for fruit products manufactured in the country was done for the Agricultural Marketing Adviser to the Government of India.

I. RESEARCH AND INVESTIGATION

1. Soils

Soil Map of India.—The preliminary map submitted to the agricultural chemists in the different provinces for check and correction was received back towards the close of the year. A fresh map incorporating the suggestions was under preparation.

Soil investigations.—Dealing with comparative soil studies it was reported last year that apart from the zonal types of soil a separate and distinct type of soil could be detected. The analytical data of clays separated from these soils show evidence for a definite type designated calcareous soils for those containing upwards of 10 per cent calcium carbonate in them. These soils have very low clay content and the clay gets more and more quartzose with depth.

Soil survey of the Delhi and Karnal Experiment Stations.—The layout of the whole of the farm areas at Delhi and Karnal having been completed, a soil survey of the farms was commenced, to provide the basis for the study of soil fertility problems in terms of relationship between soil and crop performance. A system of notation by incorporating rounded figures of mechanical analysis to denote the composition was adopted.

Calcium carbonate content of soils in relation to the formation of alkaline soils.—Contrary to the belief that alkaline soils with a high pH and high sodium content are not formed in soils containing large quantities of calcium carbonate, alkaline patches have been noted to develop in some fields at Pusa. Profile studies of these were taken up to elucidate the mechanism of alkali formation.

Spectroscopic analysis of soils for minor or trace elements.—Micro-analysis and spectroscopic examination of soils collected for the comparative studies from virgin and cultivated areas, have been taken up. The use of spectroscope in the determination of soil colour is being investigated.

Relation between microbiology and soil fertility.—The study of the microbiological aspects of soil fertility of the Permanent Manurial Plots was commenced to evaluate in the first instance the influence of manurial treatment and cropping for a number of years on the nature of the microbiological equilibrium and its relationship to crop yields.

The orders of soil fertility as shown by crop yields are different for *rabi* and *kharif* crops. They are shown below in their descending order of yields from the differently fertilised plots :—

Rabi crop	*Kharif crop*
Plot 16 A Green manure+Superphosphate	Plot 3 A Farmyard manure.
Plot 10 A Complete minerals	Plot 10 A Complete minerals.
Plot 3 A Farmyard manure	Plot 16 A Green manure+Superphosphate
Plot 12 A Green manure	Plot 12 A Green manure.
Plot 7 A Potash.	Plot 7 A Potash.
Plot 13 A No manure	Plot 13 A No manure.

The order of superiority of green manure plus superphosphate to complete minerals as shown by *rabi* crop yields is reflected in the total number of organisms, azotobacter and fungi and in physiological activities as judged by ammonifying, nitrifying and carbon-dioxide-evolving power of the soils. In these respects green manure plus superphosphate stood first and the complete mineral stood second. In regard to nitrogen fixation the order is reversed. In respect of *kharif* yields there is no consistent relationship between biological counts, bio-chemical activity and crop yield.

Samples of soils collected in the months of May and July showed loss of nitrogen on incubation for two months, while samples collected in October showed gain on incubation. No correlation is seen in the results between total organism counts and carbon-dioxide evolved but there is some relationship between the nitrogen content and carbon-dioxide evolution.

In general, bacterial activity is more in the rhizosphere than in the arhizosphere.

Defective nitrification in some soils.—It was previously reported that certain soils in a belt running across the country showed defective nitrification. The moisture requirements of these soils for optimum nitrification were found to be higher than that of a third of the saturation capacity of soils, at which laboratory investigations are usually carried out.

Bacteriophage of root nodule organisms.—No bacteriophage could be obtained from the nodules of berseem grown either for the first time or in rotation once in three or four years ; while bacteriophage was evident in nodules of berseem grown continuously in a field for several years.

2. Manures, Fertilizers and Crops

Nitrogen fixation by maize.—In continuation of previous work a field experiment was conducted to compare the effect of growing maize and sann-hemp on the succeeding crop of wheat. When the crops were ploughed into the soil as green manure either crop was equally effective. When, however, the crops were removed from the land and wheat was sown in the plots, the average yield of wheat from the sann-hemp plot was slightly more than that from the maize plot. The difference was, however, not significant.

Fixation of phosphate by soils.—The soils of the semi-arid and humid zones show the greatest amount of fixation with diammonium hydrogen phosphate, while the soils of the arid zone fix only two thirds of this quantity and the soils of the perhumid zone show the least amount of fixation, the quantity fixed being less than half of that fixed by the soils of the semi-arid zone.

On the basis of colour classification of soils, the largest amount of phosphate is fixed by black soils, while the brown, red, pink and grey soils fix about two-thirds of the quantity fixed by the black soils. There is a definite relationship between pH and phosphate fixation, which increases with the pH, showing the maximum amount of fixation between pH 6·5 and 7·5. Above 7·5 the amount of phosphate fixed tends to decrease. Phosphate fixation increases with the clay content, total base exchange capacity and exchangeable calcium of the soils. Fixation increases with the iron content of the hydrochloric acid extract of the soil and varies inversely with the silica/sesquioxide ratio.

Composition of some Indian Potato varieties.—In connection with the potato-breeding work sixty-three varieties of potatoes were examined. The starch content of the potatoes varied from 37·64 per cent to 79·38 per cent on the dry basis. The majority of the varieties had their starch content between 50 to 70 per cent. High starch values are associated with low moisture content on fresh weights of tubers. Protein content of tubers varied from 6·7 to 23·2 per cent on dry weight. Generally, the relationship between the starch content and protein content is an inverse one. The rough and ready formula usually applied for estimating starch in potatoes (starch = dry matter—5·75) does not hold good in many of the samples examined.

Sampling and analytical errors.—Soil and crop samples were collected from 136 plots of the permanent series of manurial experiments at Pusa. Of these, two hundred individual and composite samples of gram from 40 plots were analysed for moisture, ash, sand, nitrogen, phosphate and potash and the analytical data was submitted to statistical examination. In most cases the residual variances for values of composites were greater than the average values.

An investigation of personal errors in the simple colorimetric estimation of nitrate nitrogen was started. The tests were carried out by analysts of different ages and experience and at various times of the day. Significant variations were observed among the results due to different analysts as well as to different hours of the day.

The accuracy of the method of estimating the bacterial numbers and the error or variation involved in the plate method and the direct counting methods were investigated. The ratio method for direct counting developed by Thornton and Gray with some modifications were most satisfactory. The ratios obtained from parallel microscopic fields are distributed at random while the organisms themselves are not distributed at random in the films.

The number of organisms obtained by direct counting method were as much as 100 times more than those obtained by the plating method.

The error obtained by the direct counting method was about 1 per cent while the error obtained by the plating method was 2 to 3·5 per cent.

II. INVESTIGATIONS ON AGRICULTURAL PRODUCTS

Sugarcane gur investigations.—Evidence was obtained that sugarcane juice and *gur* contained substances other than sucrose and glucose which affect polariscope readings. The nature of these substances was under investigation.

Conditions for maximum elimination of non-sugars from the juice by precipitation were studied. The valency of the precipitating ions, the pH of the juice and the temperature are directly connected in the coagulation of colloidal impurities. The isoelectric points of these colloids appear to be at pH 4·0, salts with complex ions are more effective in inducing precipitation than salts with simple ions.

III. ROUTINE AND ADVISORY

Six hundred and forty six samples were analysed and reported upon during the year.

Feeding stuff.—Samples of " star grass " analysed at different periods of growth showed that HCN content is ordinarily dependent upon the age of the crop and feeding with immature grass is quite harmful. The fully mature grass could be safely fed to cattle.

Manures.—Briquettes of mixed activated and digested sludge prepared by the Sewage Disposal Works, Kilokri, had marked manurial properties, they were easily broken on slight pressure and addition of water rendered them quite plastic and suitable for thorough admixture with soil when used as manure.

Potato.—Potatoes of different varieties were found to have different amounts of vitamin C contents. Vitamin C is slowly inactivated on storage and diminished as the period of storage is increased.

IV. PROGRAMME FOR 1941-42

1. Comparative studies on soils formed under different conditions of temperature, rainfall, and evaporation.
2. Studies in carbon and nitrogen fixation in soils.
3. Investigations on the chemistry of sugarcane and manufacture of gur.
4. Investigations on sampling and analytical methods.

REPORT OF THE IMPERIAL MYCOLOGIST

(G. Watts Padwick)

I. DISEASES OF PLANTS

1. Wheat

Testing of varieties for resistance to loose smut was continued, fifty-four varieties being included. Five varieties have shown no infection over four years ; three selections have maintained their resistance this year. Ten other varieties have shown no infection since they were first included in the tests in 1938-39, and selections among four other varieties are showing promise.

2. Barley

Tests were made of the efficacy of the following methods in controlling covered smut, caused by *Ustilago Hordei* (Pers.) Lagerheim :—

(*a*) Sulphur dust, 300 mesh (*b*) Formaldehyde dust (*c*) Agrosan G (tolylmercuriacetate plus ethylmercurichloride) (*d*) Hot water treatment (*e*) Formalin steep.

Experiments were conducted at Delhi and Karnal. At Delhi the best results were obtained by Agrosan G followed by sulphur dust ; at Karnal the relative position of the two was reversed.

3. Pigeon-pea

Fourteen varieties were tested for resistance to wilt (*F. udum* Butler) and wilting varied from nil to 100 per cent. Five varieties showed less than five per cent wilt, and six varieties showed over 50 per cent.

4. Sann-hemp

Eight varieties of sann-hemp were tested for their resistance to wilt [*F. udum* Butler var. *Crotalariae* (Kulkarni) Padwick]. All showed over 25 per cent infection.

5. Gram

The general level of infection in the gram wilt (*Fusarium orthoceras* App. et Wr. var. *Ciceri* Padwick) experiment was lower this year than on the two previous years, but confirmed the high susceptibility of varieties I. P. 9 and I. P. 26 and I. P. 29 which had respectively 51, 34 and 66 per cent infection. Imperial Pusa 28 was again intermediate, with 11 per cent infection.

Observations were made on the incidence of gram wilt at Karnal and Delhi in relation to the moisture content of the soil. There was a high correlation between wilt and subsoil dryness, although there was also evidence of *Fusarium* attack.

For the third season observations on wilt were made in the Imperial Agriculturists' date-of-sowing experiment. Results confirmed the previous conclusions that late sowing reduces wilt.

The yield from the crop sown on 28th October was nearly 50 per cent greater than that from the one sown on 23rd September, despite the fact that there was decidedly better germination from the first sowing.

The fungus causing foot-rot of gram has now been fully described and named a new genus, *Operculella*, the species causing foot-rot being *O. Padwickii* Kheswalla. Tests of thirty-two varieties showed that none was completely resistant to the disease.

6. Tobacco

Attempts were again made to render white-flies (*Bemisia gossypiperda*) infective for leaf-curl virus by feeding them on juice extracted from infected plants. The apparent partial successes of last year were not repeated, and it seems very doubtful whether white-flies can be made infective in this way.

7. Potatoes

Observations of a preliminary nature was made on the virus diseases of potato in Delhi, some parts of the United Provinces and the Punjab. The incidence of diseases, especially mosaics and leaf-roll, was recorded.

Arrangements to get the differentials for the identification of potato viruses were made. Some virus-free material has already been received from abroad.

Testing of resistance of potatoes to early-blight, caused by *Alternaria solani* (Ell. et Mart.) J. et Gr. and of tubers to rotting caused by *Fusarium* spp., was continued.

8. Sugarcane

The work on sugarcane diseases was continued under the scheme financed by the Imperial Council of Agricultural Research.

The red-rot epidemic continued with great severity in northern Bihar and eastern United Provinces. The variety Co. 213 was the most badly affected, but Co. 210, 299, and 331 have been found attacked in northern Bihar and Co. 210, 299, 445, 537, 312, 370, 421, 331, 393, 442 and Co. S. 5 in the United Provinces. Stray cases were also observed in Co. 312 and Co. 356.

From field material collected and examined, much of interest from the pathological viewpoint has now emerged. It has been noticed that there is a quite high degree of association between red-rot, caused by *Colletotrichum falcatum* Went, and wilt, caused by *Cephalosporium Sacchari* Butler. There is evidence that a good deal of secondary red-rot infection occurs through the nodal region. Out of about 1000 affected canes examined from sixty-nine localities in the United Provinces and Bihar, 228 showed infection of the upper nodes of the stem in the absence of any infection at the base. A light coloured and highly sporulating strain of *Colletotrichum falcatum* was predominant in the isolations made, numbering nearly one thousand.

Various experiments are in progress to determine the sources and modes of red-rot infection. One of the most important of these experiments was the planting of healthy setts in soil contaminated with pure cultures of the fungus

and with debris of diseased canes from epidemic areas. In spite of an exceptionally hot and dry season which one would not suppose to be favourable for development of the disease, some shoots of the varieties Co. 213 and 445 planted in such soil are drying up and showing typical red-rot symptom. The practical significance of this finding is obvious. Experiments have now been laid out to determine the length of time for which such debris in the soil may remain infective.

Varietal trials for resistance to red-rot (*Colletotrichum falcatum* Went) wilt (*Cephalosporium Sacchari* Butler) and smut (*Ustilago scitaminea* Sydow were continued. Sixty-eight varieties were tested against red-rot and wilt and fifty-five against smut.

Conclusions reached in previous years on the effectiveness of roguing in controlling sugarcane smut received confirmation this year. Over an infected area of 13·6 acres only forty-four smutted clumps were rogued out in April and May, 1941, as compared with 319 for the corresponding period in 1940.

9. Pears

A serious die-back and shedding of bark of pears (*Pyrus communis*), which has been causing much damage in recent years, was investigated at the request of the Agricultural Officer, North West Frontier Province. It was found that the disease was due to a species of *Cytospora*. Further work on the identity of the fungus is being carried out at Delhi ; a study of control measures is very essential in the North West Frontier Province.

10. Hibiscus sabdariffa

A leaf disease of the crop observed at Dacca was found to be caused by new species of *Phyllosticta*.

II. BIOLOGICAL CONTROL

An experiment was conducted to determine whether *Fusarium udum* Butler, cause of pigeon-pea wilt, and *F. orthoceras* var. *Ciceri*, cause of gram wilt, can be reduced in quantity or virulence by the abundance of other organisms. There was no indication of any control of wilt through addition of farmyard manure or of a large quantity of spores and mycelium of species of *Aspergillus* and *Trichoderma* which showed marked antagonistic effects in Petri-dish cultures.

III. TAXONOMY

Studies on the Peronosporales, Pucciniales, Ustilaginales, several genera of Ascomycetes, Pestalotia and Monochaetia were continued.

IV. ADVISORY

Two hundred and fifty-one specimens of diseased plants were examined for officers of the Departments of Agriculture and University professors.

Twenty-three cultures were identified for workers in India and abroad.

V. MISCELLANEOUS

Workers in India and abroad were supplied with eighty-six living cultures of fungi and one hundred and thirty-five herbarium specimens. The culture collection was enriched by the addition of fifty-five cultures, and the herbarium collection by two hundred and three specimens.

Nineteen papers intended for publication in various journals were refereed.

VI. PROGRAMME OF WORK FOR 1941-42

1. *Varietal Resistance tests*

Loose smut, flag smut and Indian bunt of wheat ; wilt of pigeon-pea and gram ; foot-rot of gram ; red-rot, wilt, smut and mosaic of sugarcane ; early blight, late blight and storage rots of pottatoes.

2. *Fundamental work supplementing varietal resistance tests*

(*a*) Determination of physiologic forms of *Ustilago Tritici* (Pers.) Rostrup, *Urocystis Tritici* Koernicke, *Neovossia indica* (Mitra) Mundkur, *Fusarium udum* Butler, *F. orthoceras* Wr. et Rkg. var. *Ciceri* Padwick, *Colletotrichum falcatum* Went, *Cephalosporium Sacchari* Butler and *Ustilago scitaminea* Sydow.

(*b*) Improvements of methods of infesting field soil with *Fusarium udum* Butler and of infesting wheat with *Neovossia indica* (Mitra) Mundkur for purposes of infection tests.

3. *Study of possible methods of infection and sources of inoculum of red-rot, wilt, and smut of sugarcane*

4. *Survey work on sugarcane diseases especially to correlate disease incidence with variety and soil and climatic conditions*

5. *Work on virus diseases of crop plants*

(*a*) Identification of the viruses of potatoes by the use of differential hosts and the physical and chemical properties of the viruses.

(*b*) Observations on the incidence of insect vectors on potatoes.

(*c*) Observations on tomato and other viruses.

6. *Experiments on the survival of soil-borne plant pathogenes and the factors influencing development of diseases such as gram wilt and red-rot of sugarcane*

7. *Taxonomic work*

Some of the following and related genera will be under study during various seasons of the year :—

Phytophthora ; *Alternaria* ; *Erysiphe* ; *Fusarium* ; *Urocystis* ; *Synchytrium* ; *Cystopus* ; *Peronospora* ; *Nectria* ; *Phacidium*.

8. *Fungicides*

The efficacy of well known fungicides will be tested under Indian conditions.

9. *Soil fungi*

A study of fungi in the permanent manurial trials at Pusa, in collaboration with the Imperial Agricultural Chemist.

10. *Routine work of a general nature*

(*a*) Identification of specimens and cultures received.

(*b*) Preparation of a host-index of Indian fungi.

(*c*) Reviewing and indexing of published work on plant diseases.

(*d*) Additions to and maintenance of the herbarium and culture collection.

(*e*) Advice and assistance to the Imperial Council of Agricultural Research.

(*f*) Training of students.

REPORTOF THE IMPERIAL ENTOMOLOGIST

(Hem Singh Pruthi)

I. INTRODUCTION

During the year under report, research work was carried out almost on the same lines as in the previous year but due to the outbreak of a fresh cycle of the desert locust in the autumn of 1940, considerable attention had to be given to work on this pest. Assistance was given to the concerned authorities in the Provinces and States in setting up organisations to fight the locust menace. Several locust classes were held for the training of the officers of Agriculture, Revenue and Co-operative Departments of various Provinces and States and the general public.

II. SPECIAL INVESTIGATIONS

1. Ecological studies on spotted bollworms (*Earias* spp.) of cotton and their important parasites

Further observations were made on the behaviour of bollworm *Earia fabia* Stoll and of its parasite *Microbracon greeni* var. *lefroyi* (D. & G.) at constant temperatures of 16°, 20°, 25°, 30° and 35°C., and saturation deficiencies of 0, 3 and 14 mm.

As was reported last year, the larvae of *Platyedra gossypiella* could form a suitable alternate host for the breeding of the parasite *Microbracon greeni* var. *lefroyi* and most of the general breeding of the parasite was done on this host. It was further discovered that instead of offering *Earias* larvae inside the pod for oviposition of the parasite, which sedulously avoided ovipositing on naked larvae, one could offer full-grown larvae in prepupal stage just when they had spun a thin cocoon over them but had not yet changed to pupal stage.

Regarding the incidence of *Earias* spp. and *Microbracon greeni* var. *lefroyi* during the months of May and June, the hottest and driest period of the year, the population of the bollworm was fairly high but the parasite was extremely rare. With the first showers of rain at the end of June and consequent fall in temperature and rise in relative humidity, the incidence of the parasite began to rise and that of the host started to decline.

2. Fatal temperatures for the pink bollworm *Platyedra gossypiella* (Saund.)

The investigation reported last year was continued and the influence of moisture at various temperatures was specially studied. Under relatively dry conditions the larvae of the pink bollworm resist high temperatures and therefore longer exposures than under humid conditions would be required to ensure their complete mortality. For instance, while an exposure of cotton seeds for 24 hours to 45° C. is completely fatal to the larvae if the saturation deficiency of air is 3-14 mm., it is not so if the saturation deficiency is 32 mm.

With the heat treatment remaining the same, there was always higher mortality among larvae inside American seeds as compared to those inside *desi* seeds. It was further found that the viability of cotton seeds was not affected materially up to an exposure of about 20 minutes to 65°C., or 7 minutes to 80°C. An exposure of even 9 hours to the sun on a *kuchha* floor during May (the hottest month in Delhi) did not prove completely fatal, if the day although otherwise clear followed a shower of rain which made the atmosphere cooler. On the other hand, under good conditions of heat transmission, only half an hour's exposure during a comparatively cool month of March sometimes gave 100 per cent mortality.

3. Insect Vectors of Leaf-curl disease of Tobacco in North India

The control of the white-fly vector Bemisia tabaci (Gen.)

Continuing the work described in the previous reports on this species as B. Gossypiperda spraying experiments were carried out to discover suitable methods of controlling the white-fly and thereby the leaf-curl disease.

The following were the tentative conclusions :

(*a*) The spraying should be started in the nursery stage and continued till the end of October.

(*b*) Fish-oil rosin soap (in 1 in 12·5 gallons of water) gave better results than nicotine sulphate (1 in 850).

(*c*) The behaviour of the seedlings kept covered with muslin in the nursery bed was very errative. The seedlings which were sprayed with nicotine sulphate proved to be least infected, whereas those sprayed with fish-oil rosin soap had the heaviest incidence of the disease, more than even in those seedlings kept exposed to the infestation by the white-fly throughout.

Minimum number of the white-fly and the period of its feeding sufficient to transmit the disease.—It was found that fifteen minutes' feeding on tobacco and forty-five minutes' feeding on *Ageratum* was sufficient to enable the vector to transmit the disease to healthy tobacco. Shorter periods than the above were not tested. Further, white-flies which had fed on diseased tobacco for a period of fifteen minutes remained viruliferous almost throughout their life.

Seasonal incidence of the white-fly and leaf curl.—From the data collected, it was evident that, as in the case of previous two years, there was distinct correlation between the incidence of the disease and the population of the white-fly.

4. Studies on Insect populations

The study of fluctuation in insect population was initiated as one of the major investigations during the year under report.

The spotted bollworms, *Earias fabia* and *Earias insulana* have been selected for the study.

Besides the work on spotted bollworms of cotton, the development of a technique for determining population of adult *Pyrilla* in the field has also been

taken up in connection with biological control experiments which are in progress against this pest under the Sugarcane Pest Scheme.

5. Immature stages and life-histories of Indian Insects

Over 130 species found on various hosts were under study, some of the interesting species being *Phyllocnistis citrella* (Stt.) on *Citrus* spp., *Dichocrocis punctiferalis* Guen. on castor, *Arcyophora dentula* Led. on pomegranate, *Phycodes minor* Mo. and *Agnais ficus* Fabr. on fig, *Giaura sceptica* Swinh. on *Grewia asiatica*, *Sylepta lunalis* Guen. on grape vine, *Euproctis lunata* Walk. infesting castor, etc.

The colour variation in larvae of a number of Lepidopterous species was closely studied. It has been observed in many cases that the general ground colour of the larvae resembles the colour of the food though the colour patterns are specific. For example, larvae of *Heliothis armigera* when fed on pink petals of hollyhock flowers develop pink colour though the colour pattern proper to the species remain unaltered. In order that the food should have the fullest effect on larval colour, it has been found by tests in the insectary that the larvae should be fed on the particular host plant from the moment they hatch out from the eggs.

6. Pests of fruits and vegetables

The well known Ethiopean fruit fly, *Dacus ciliatus* Loew. (=*D. brevistylus* Bezzi) has been found causing serious damage to cucurbit fruits along with *Dacus cucurbitae* Coq. during the last three years at Delhi. The damage by *D. ciliatus* is expected to be serious in early summer and autumn.

The fruit fly, *Acanthiophilus helianthi* Rossi, for the third successive year seriously attacked safflower, especially during March and April. The spineless varieties (30 and 34) were again found much more susceptible to attack than the spiny ones. As the pest has been found to breed continuously on the wild safflower and does not seem to possess any other alternative host, systematic uprooting of this weed during the autumn in the neighbourhood of cultivated areas should be a very useful measure in the control of the pest. The Hymenopterous parasite, *Ormyrus* sp. (Family Torymidae) seems to exert an effective check on the multiplication of this fruit fly.

7. Biology of Parasites and Predators

The problem of host selection by *Bruchobius laticeps*, a parasite of *Bruchus analis*, a serious pest of stored grain, was under investigation. It was found that the parasites did not lay any eggs untll the host larvae were inside the grain.

The biology of *Chilomenes sexmaculata*, a common predator on aphides in Delhi, was studied. The predator preferred *Macrosiphum granarium* to any other species. A new Chalcid parasite (*Tetrastichus* sp.) was reared from the grubs and pupa of *Chilomenes*.

8. Taxonomic Studies on Indian Insects

Parasites.—Taxonomic studies on important groups of parasites were continued. The preparation of a Catalogue of Indian species of Braconidae

was in progress. Several species of the genera *Rhogas* and *Apanteles* were under study. An Ichneumonid reared from the larva of *Sphenarches caffer* (Zell.), which was also parasitized by *Apanteles paludicolae* Cam. in the Insectary, was identified as *Mesochorus facialis* Brdgman. This parasite is interesting in view of some previous record of hyperparasitism of *Apanteles* sp. by *M. facilis*. The present instance is the first definite record of hyperparasitism of *A. paludicolae*.

Of the parasites identified during the year, the following are noteworthy additions to the fauna of India: A parasite received from Mysore, and bred from cattle tick (*Ornithodoros* sp.) was identified as *Ixodiphagus mysorensis* Mani. The genus *Ixodiphagus* has not been recorded from India before. A parasite on the larvae of *Cosmophila sabulifera* infesting jute at Dacca was identified as *Litomastix gopimohani* Mani. This genus, not previously known from India, is remarkable in that the phenomena of polyembryony is known to be a mode of reproduction as in some species of this genus.

An important parasite of *Plecoptera reflexa* in forest areas received from the Forest Entomologist, Dehra Dun, was identified as *Euplectrus plecopterae* Mani. Two new species, one Encyrtid and the other a Cynipid hyperparasite were bred from the larvae of *Sphaerophoria javana* Wied., predating on *Aphis laburni* Kaltenbach in Delhi.

Aphidae.—A survey of the Aphidae found in Delhi and its environs yielded about twenty species, of which *Rhopalosiphum pseudobrassicae* (Davis) on cruciferous plants, *Myzus persicae* (Sulz.) on potato and tobacco, *Aphis maidis* Fitch on maize and juar and *Aphis laburni* Kalt. on Leguminous crops were most common.

Jassoidea.—A large collection of specimens of the genus *Empoasca*, which includes a number of injurious species, from various parts in north India was closely studied. Besides the most common species, *Empoasca devastans* Dist., seven other species new to science were described.

9. Insecticides and Fumigants

The efficacy of a number of old and new mineral insecticides and fumigants was studied under different conditions during the year and several insecticides of vegetable origin were also under investigation and trial.

III. GENERAL OBSERVATIONS ON INDIAN INSECTS

The following insects were observed for the first time on economic plants at Delhi :—

Thevetia alecta Linn. on grape-vine (breeding), *Celerio lineata* (Esper.) on *Thevetia neriifolia* (feeding) ; *Anticarsia irrorata* Boisd. on *Phaseolus mungo* and cowpea (breeding), *Giaura sceptica* on *falsa* ; *Grewia asiatica* (breeding) ; *Taragama siva* Lef. on guava (feeding) ; *Sphenoptera laferti* on peach (feeding), *Arcyophora dentula* Led. on pomegranate (breeding).

At Pasni on the south coast of Baluchistan, important pests noted during December were *Gryllulus domesticus* (Linn.) on *Aruva javanica* ; *Acherontia styx*

Westw. on *Withania roagulans*, *Heliothis armigera* (Hübn.) on bottlegourd and tomato, *Brachychungis carthami* Das on *Sphaerocoma ancheri* and *Hodotermes macrocephalus*.

IV. LOCUST WARNING ORGANISATION

The desert locust *Schistocerca gregaria* Fursk. assumed gregarious phase in the summer of 1940, after remaining in the solitary phase for nine years. The centre of development of this change was in Sind and Rajputana. The staff and other resources of the Locust Warning Organisation were temporarily increased, thus ensuring intensive survey work.

The locust population in all the permanent breeding areas in Baluchistan in the spring and early summer of 1940 was rather low and nowhere any incipient swarming was observed. In the desert tracts of Sind and Rajputana also the locust population was lower than even in the previous year up to May 1940. Immigrants from the west began to appear early in June as usual and with widespread precipitations received in May and June, the soil moisture conditions all over Sind-Rajputana became suitable for oviposition. In July hoppers of all ages were observed in fair numbers in the Thar-Mallani and Bikaner areas. A sudden increase in locust population presumably as a result of first summer generation and arrival of some more migrants from west was recorded in July and the population density shot up to 8,000 per sq. mile in Thar-Mallani and 2,080 in Bikaner areas. A somewhat remarkable feature observed in this month was that a number of the locusts collected from some localities showed intermediate and gregarious E/F ratios. Besides this, a few small loose swarms of sexually mature yellow locusts with gregarious features appeared in Suratgarh and Lunkaransar tehsils of the Bikaner State in the second week of July. In August and September some more yellow swarms were seen in these areas as well as in some parts of Jaisalmer. Concentrated oviposition by these swarms took place over wide tracts and the hoppers bore gregarious characteristics and the adults which developed from them were pink in colour and formed swarms in the beginning of October.

In Tharparkar and Mallani areas also breeding started in July and was most active in the Chachro. Kantio area where innumerable solitary forms and bands of gregarious hoppers of IV-V stages were found in September which gave rise to pink swarms.

It is rather difficult to accurately determine the origin of the yellow locust-which appeared in Bikaner State in July. Judging from the poor spring breeding in Baluchistan it is clear that these swarms did not originate from that area. On the other hand, the conditions being extremely favourable for breeding in Sind-Rajputana in early summer it is possible that concentrated oviposition in some sparsely populated areas by grey migrants towards the end of May or by the home-bred adults in spring might have resulted in the development of gregarious adults in the first half of July. If this be so, it is evident that in case the conditions are favourable, the desert tracts of Sind-Rajputana can serve as an outbreak centre independent of Baluchistan. This is contrary to current belief. The other source of origin of the yellow swarms described above may be extra Indian. The history of immigrants swarm in 1941 shows

that this source was really very important, but due to war conditions no detailed information was or is available for the first half of 1940 from Iran, Muscat, Arabia, etc.

The swarms which originated in the autumn of 1940 from Bikaner and Jaisalmer States in Rajputana and Tharparkar district of Sind flew towards the west and visited some western districts of Punjab and N. W. F. P., almost whole of Sind and Baluchistan. Apparently some swarms went further west and south-west into Iran, Oman, etc. Some flew towards the east visiting some southern States of Rajputana, south-eastern districts of the Punjab and some western districts of United Provinces. The swarms were most active in November and their activities continued up to the beginning of January 1941.

Extensive surveys of the areas which had been visited by swarms were carried out during the following winter and in all the areas locusts were traceable, the maximum population in Mekran coast was 26,000 per sq. mile, in Jhalawar 10,000 and in cultivated fields of Kachhi 77,000. In Sind-Rajputana the highest population was 21,000 at Arjansar (Bikaner State).

Spring breeding (1941) was particularly heavy in Jhalawar and Kachhi areas of Baluchistan where soil remained suitable for oviposition up to the end of May owing to favourable rainfall and periodic flood water received in that region. In Mekran the winter-spring precipitation was rather deficient and therefore there was light breeding in most of the localities except in Dasht-Gwadar area.

In some tehsils of Kachhi breeding occurred on a very extensive scale, the hopper population being 78,00,000 per acre in some places. About 50 per cent of the IV-V stage hoppers were of gregarious phase. Several lakhs of adult locusts and millions of hoppers were destroyed by beating, baiting and burning and thereby the population was reduced considerably. In spite of large breeding capacity of the locust, the maximum population in June 1941 was only 11,000 per sq. mile. Thus by continuous and systematic control work the population was reduced considerably and incipient swarming prevented. Therefore, the chances of eastward migration of locusts especially of gregarious phase to Rajputana were reduced to the minimum.

In Rajputana, light breeding occurred in the spring of 1941 in Bikaner area only.

Some migrant locusts started appearing about the end of May in Jodhpur and other areas in Rajputana. But the biggest increase in population was effected by yellow swarms obviously extra-Indian in origin migrating from west as first wave at the end of June, in the coastal areas of Sind and Kathiawar. A second wave of eastward migration was recorded in the second half of July, 1941, first in the coastal parts of Baluchistan. These immigrant swarms flew all over Rajputana and Sind, eastern districts of Baluchistan, western districts of the Punjab and N. W. F. P. The swarms started concentrated oviposition and breeding almost immediately in areas of good rainfall. Gregarious breeding of the first generation hoppers of the year is in progress in Sind-Rajputana areas at the time of writing this report and a second generation is expected before the summer (1941) is over.

V. IMPERIAL PUSA COLLECTION

During the year under review about 380 named species which had not been represented in the Collection before were added. A large number of outside workers came to consult the Collection.

VI. ADVISORY

About one hundred consignment of insects comprising about 1,000 species were received from the Provincial Entomologists and other workers in different parts of India and identified as far as possible.

VII. PROGRAMME OF WORK FOR 1941-42

Research work will be continued more or less on the same lines as during the year under report. Work on Termites will be initiated.

REPORT OF THE SECOND ENTOMOLOGIST (DIPTERIST)

In charge of the Scheme for Research on Insect Pests of Sugarcane

(Taskhir Ahmad)

Work on sugarcane pests was continued at New Delhi and the sub-stations, Karnal, Pusa and Coimbatore. Some field experiments were also conducted at Palhera farm (Meerut), Sehore (Bhopal) and Sugauli (Bihar) in co-operation with the local authorities.

1. General observations on the incidence of pests

General observations on the incidence of various pests of sugarcane and their parasites throughout the period of the growth of the crop were taken at various substations. Most noteworthy among these are the new records at Coimbatore of *Aspidiotus glomeratus* Green, *Antonina indica* Green, *Odonaspis* spp., and *Pseudococcus saccharicola* Takah., as pests on sugarcane, *Nimboa basipunctata* Withyc., as predators on eggs of *Pyrilla* spp., and *Anagyrus saccharicola* Timb., as parasite on adult females of *Ripersia sacchari* Green.

2. Field experiments on varietal resistance at Karnal and Pusa

Field experiments to study the seasonal incidence of borers and termites and the resultant loss in weight to the mature canes at harvest were carried out by taking periodical observations during the growth of the crop and final observations at harvest, on five varieties of cane *viz.*, Co's. 285, 312, 313, 331 and 421 at Karnal and two varieties *viz.*, Co. 210 and Co. 331 at Pusa, grown in randomized replicated plots.

3. Field experiments at Meerut and Bhopal

Field experiments to note the incidence of borers and termites during the growth of the crop and at harvest time, under different cultivation treatments were carried out at Palhera farm (Meerut) and Sehore (Bhopal). At Palhera farm, variety Co. 312 was planted in replicated plots according to (A) Java trench method and (B) Local flat method ; at Sehore, varieties Co. 244 and Co. 421 were planted according to (*a*) Deep furrow method, and (*b*) present Mysore method.

4. Fecundity studies

Fecundity studies on the more important lepidopterous borers of sugarcane were carried out at New Delhi, and also at Pusa and Coimbatore. The average number of eggs noticed by dissection in the different species of borers varied from 84 to 190, while the number noticed in oviposition experiments varied from 118 to 343.

5. Studies on the structure of midrib in varieties showing differential susceptibility to *S. Nivella*

Further studies on the midrib hardness as a factor in determining the resistance of different varieties to the attack by *Scirpophaga nivella* were carried out. Sections of midribs of varieties Co's. 285, 312, 313, 331 and 421

obtained periodically from the replicated plots at Karnal were examined. Co. 331, Co. 421 and Co. 285 which were found to be more resistant had the larger and more closely arranged vascular bundles with the associated sclerenchyma sheath and cap in greater prominence than in the less resistant varieties, Co. 312 and Co. 313.

6. Biological Control Research

The following new parasites were collected and reared on the hosts mentioned against them.

Name	Host and Habit	Locality
1. *Hypolethria ramachandrai* Mani	In decaying tunnels of *Sesamia uniformis* in sugarcane.	Sugauli (Bihar).
2. *Encarsia isaaci* Mani . .	Nymphs of *Aleurolobus barodensis*	Cuttack (Orissa)
3. *Encarsia muliyili* Mani .	Ditto . . .	Do.
4. *Eretmocerus delhiensis* Mani .	Nympps of *Neomaskellia bergii*.	New Delhi.
5. *Telenomus saccharicola* Mani .	Eggs of a Pentatomid bug on sugarcane . .	Do.
6. *Bephratoides saccharicola* Mani	From cocoons in tunnels of *Scirpophaga nivella* . .	Pusa (Bihar).

Biological control experiment with *Trichogramma minutum* against the stem borers (mainly *Argyria sticticraspis*) and the root borer, *Emmalocera depressella* were carried out at Sugauli. The results at harvest time based on yield of cane were significantly in favour of *Trichogramma*. The data collected during the crop's growth is being analysed and the conclusions derived therefrom will be submitted later.

Introduction of predatory insects (*Brumus suturalis and Chrysopa* sp.) into the Bhopal State for the control of Pyrilla gave encouraging results.

7. Regional survey of sugarcane borers

A detailed report based on the statistical analysis of the data received during the year 1939-40 from seven regions out of the fourteen, was prepared and submitted. Statical analysis of the data from the remaining seven regions was in progress. Preliminary reports on the borer survey data for the period April October 1940, and November 1940 to March 1941 were submitted by the second Entomologist (Dipterist) and Professor Mahalanobis respectively.

8. Collation of records from Provinces and States

A summary of the work on sugarcane pests done in provinces and States during the year 1939, was prepared and sent to the Imperial Council of Agricultural Research.

APPENDIX I

Gazetted Staff of the Institute

Director	Rao Bahadur B. Viswa Nath	

Agriculture

Imperial Agriclturist	Mr. C. H. Parr	Joined on 24th August, 1940.
Agricultural Experimentalist	Mr. R. D. Bose	The post is temporary.
Assistant Agriculturist	Mr. Arjan Singh.	
Statistician	Mr. P. V. Krishna Iyer.	
Farm Superintendent, Karnal	Mr. A. R. Khan	
Cattle Superintendent, Delhi	Mr. J. D. Sampathkumaran.	
Cattle Superintendent, Karnal	Mr. N. P. Fernandez.	
Engineering Assistant	Mr. A. K. Kaul.	

Botany

Imperial Economic Botanist	Dr. B. P. Pal.	
Second Economic Botanist (Cytogenetics)	Dr. S. Ramanujam.	
Assistant Economic Botanist	Mr. R. B. Deshpande (*Offg.*)	In place of Mr. R. D. Bose appointed to the temporary post of Agricultural Experimentalist.
2nd Assistant Economic Botanist	Dr. J. J. Chinoy.	
Superintendent, Botanical Sub-station, Pusa	Mr. Hukum Singh (*Offg.*)	

Agricultural Chemistry and Soil Science

Imperial Agricultural Chemist	Rao Bahadur B. Viswa Nath.	
Assistant Agricultural Bacteriologist	Dr. S. V. Desai.	
Assistant Agricultural Chemist	Dr. S. L. Dass.	
Second Assistant Agricultural Bacteriologist	Mr. A. C. Ukil.	

Entomology

Imperial Entomologist	Dr. H. S. Pruthi.	
Second Entomologist (Dipterist)	Mr. P. V. Isaac.	
Biological Control Research Officer	Dr. J. A. Muliyil	The post is temporary.
Assistant Entomologist	Dr. Taskhir Ahmad.	
Second Assistant Entomologist	Dr. E. S. Narayanan.	
Superintendent, Locust Sub-station, Karachi	Dr. S. Mukherjee.	
Assistant Locust Entomologist	Dr. K. D. Baweja.	

Entomology—*contd.*

Assistant Locust Entomologist .	Mr. H. L. Bhatia . .	The post is temporary in the expanded Locust Warning Organisation.
Assistant Entomologist (Insect population studies) . . .	Dr. S. S. L. Pradhan .	The post is temporary.

Mycology and Plant Pathology

Imperial Mycologist . . .	Dr. G. Watts Padwick.	
Assistant Mycologist . . .	Dr. M. Mitra.	
Second Assistant Mycologist .	Dr. B. B. Mundkur.	
Plant Pathologist for Sugarcane diseases	Dr. B. L. Chona . .	The post is temporary.
Assistant Sugarcane Mycologist .	Mr. L. S. Subramaniam .	Do.
Assistant Plant Pathologist . .	Dr. R. S. Vasudeva . .	Do.

Sugarcane Station, Coimbatore

Sugarcane Expert . . .	Rao Bahadur T. S. Venkatraman.	
Second Cane Breeding Officer .	Mr. N. L. Dutt.	
Assistant Sugarcane Expert . .	Mr. R. Thomas.	
Geneticist	Dr. N. Parthasarathy .	The post is temporary.

APPENDIX II

Training of students and research workers during 1940-41

(a) Awarded Post-graduate Diploma of the Institute

Name	*Subject of Thesis*
1. M. J. Deshmukh (Central Provinces)	Studies concerning the seed setting and agricultural value in Berseem and allied species.
2. Mohd. Jaffar (Hyderabad State) .	An interspecific cross between *Triticum vulgare* Host. and *T. Vavilovi* Jakub. : its segregation and importance.
3. Y. R. Mehta (United Provinces) .	Studies in vernalisation of mustard, gram and wheat.
4. H. C. Mirchandani (Sind) . .	A study in the variability of Afghanistan wheats.
5. M. P. Narasimha Rao (Madras) .	Studies in the Indian Oleiferous *Brassicae*.
6. Harbhajan Singh (Punjab) . .	Part I—Studies in the egg-plant (*Solanum Melongena* L.). (*a*) Floral characters and fruit formation. (*b*) Immediate effects of cross-pollination on the size of the F. seed. (*c*) Teratology. Part II—Freezing experiments with some cultivated and wild potatoes.
7. P. R. Bhagwagar (Central Provinces)	Part I—Review of Fungicides in India (including Burma and Ceylon). Part II—Studies in *Fusarium* Wilt and seedrot of gram (*Cicer arietinum* L.) in India. Part III—*Alternaria* spp. on potato in India.
8. P. L. Chaturvedi (United Provinces)	Biology of *Melangromyza phaseoli* Coq.
9. K. C. Batra (Punjab) . . .	Part I—Relationship between mechanical analysis and some single value constants. Part II—A comparative study of some more important ordinary and rapid methods of estimating exchangeable bases in soils.
10. N. G. C. Iyengar (Mysore State) .	Biochemical studies on some Imperial Pusa wheats. Part I—The effect of fertilisers and cattle manure on the protein fractions. Part II—Differences in the chemical composition of some Pusa wheats grown on different soils.
11. K. M. Mehta (Jodhpur) . .	Part I—The Relationships between mechanical analysis, moisture equivalent and sticky point in Indian soils. Part II—Comparative study of some rapid chemical methods of estimating nitrogen and phosphorus in soils with the usual official methods. (Joint author—V. N. Prasad.)
12. V. N. Prasad (Bihar) . . .	Relationship between moisture equivalent, sticky point and clay content of soils.

(b) Awarded post-graduate certificate in Agriculture

1. J. N. Misra (United Provinces).
2. N. V. Karkare (Central Provinces).
3. Ranbir Singh (Punjab).

(c) Post-graduates under training during the year

Name	*Subject*	*Date of admission*
1. K. L. Gurnani (Sind)	Agriculture	October, 1940.
2. Ch. Mohd. Amir (Punjab)	Do.	Do.
3. K. R. Chowdhury (Punjab)	Do.	Do.
4. G. P. Seth (United Provinces)	Agriculture (Sugarcane Breeding)	Do.
5. J. N. Sharma (United Provinces)	Do.	Do.
6. Sohan Bir Singh (United Provinces)	Sugarcane Breeding	Do.
7. S. Majid Ali (Bhopal)	Do.	Do.
8. A. R. Braganza (Bombay)	Botany	October, 1939.
9. K. D. Sharma (United Provinces)	Do.	Do.
10. D. Srinivasachar (Mysore)	Do.	Do.
11. Amar Singh (Punjab)	Do.	October, 1940.
12. Hari Kishore (United Provinces)	Do.	Do.
13. H. P. Srivastava (United Provinces)	Do.	Do.
14. U. Thein Aung (Burma)	Do.	Do.
15. M. V. Vachhani (Sind)	Do.	Do.
16. M. Krishna Reddy (Hyderabad)	Agricultural Chemistry	October, 1939.
17. D. K. Patel (Baroda)	Do.	Do.
18. N. M. Bose (Bengal)	Do.	October, 1940.
19. P. Thothadri (Madras)	Do.	Do.
20. M. C. Chhatrapati (Bombay)	Do.	Do.
21. C. N. Modowal (United Provinces)	Entomology	October, 1939.
22. Shamsher Singh (Burma)	Do.	Do.
23. T. D. Mukherjee (United Provinces)	Do.	October, 1940.
24. R. K. De (Bengal)	Do.	Do.
25. K. K. Nirula (Punjab)	Do.	Do.
26. A. S. Rao (Madras)	Do.	Do.
27. A. Panda (Orissa)	Mycology	October, 1939.
28. A. N. Fotidar (Kashmir)	Do.	Do.
29. S. P. Ray Chaudhury (Bengal)	Do.	October, 1940.
30. N. R. N. Dey (Bihar)	Do.	Do.
31. U. Mohanty (Orissa)	Do.	Do.
32. A. S. Fatmi (Bhopal)	Do.	Do.

(c) Post-graduates under training during the year—*contd.*

Name	*Subject*	*Period of stay*
1. Narinder Chand	Agricultural Chemistry	Two months.
2. G. L. Maheshwari (United Provinces)	Do.	Four months.
3. K. L. Sarkar (Bhopal)	Do.	Six months.
4. P. Sankaramurty	Pure and Applied Ent.	Three months.
5. H. L. Sarkar (Bengal)	Do.	Two months.
6. Reza Kazimi (Hyderabad)	Sugarcane Pests	Three months.
7. Dr. B. Singh (United Provinces)	Plant Pathology	Two months.
8. J. L. Merh (United Provinces)	Do.	One year.
9. E. Jayanetti (Ceylon)	Sugarcane Breeding	Two months.
10. T. Velauthan (Ceylon)	Do.	Do.
11. Pritam Singh (Patiala)	Agriculture	Six months.
12. B. S. Chowdhury (United Provinces)	Do.	Do.
13. Misri Lall (United Provinces)	Cattle Breeding and Management	Two months.
14. J. B. Bhattacharya (Bengal)	Tobacco Curing	Do.

(e) Honorary Research Workers

Name	*Subject of Research*
1. G. N. Pathak (United Provinces)	Cytological studies in wheat hybrids.
2. T. K. Ramamurti (Madras)	Developmental Studies in Colchicine treated gram.
3. N. S. Aren (United Provinces)	Morphology of mouth parts of Lepidoptera.
4. J. Thuljaram Rao (Madras)	Anatomy of sugarcane.
5. C. K. Dilwali	Agricultural Statistics.
6. P. L. Chaturvedi (United Provinces)	Moth borers of Sugarcane.

APPENDIX III

List of papers published during 1940-41

Ahmad, Taskhir . . . . A survey of the Insect fauna of Afghanistan.—*Indian J. Ent.*, 1940 : 2 : 159-176.

Ahmad, Taskhir and Gupta, R. L. . The Pea leaf-minor *Phytomyza atricornis* (Meigen) *Indian J. Ent.* : 1941 : 2 : 27-49.

Ahmad, Taskhir (in collaboration with Hussain, A. & Mathur C. B.) . Studies on *Schistocerca gregaria* Forsk. X. On the role of water in the Bionomies of the desert locust—*Indian J. Agric. Sci.* 1940 : 10 : 927-944.

Bhatia, D. R.. . . . . Observations on the Biology of the desert locusts (*Schistocerca gregaria* Forsk.) in Sind-Rajputana desert area. *Indian J. Ent.* 1940 : 2 : 187-192.

Desai, S. V. . . . . Production of fuel gas from organic waste materials by anaerobic fermentation. *Proc.* of *Nat. Acad. Sci.* 1941.

Deshpande, R. B. . . . . A sterile mutant in Safflower. (*Carthamus tinctorius* L.) *Curr. Sci.* : 1940 : 8 : 370-371.

Dutt, N. L. Krishnaswami, M. K. and Subba Rao, K. S. . . . On certain floral characters in sugarcane II.—*Proceedings* of the Indian Science Congress 1941.

Kheswalla, K. F. . . . Foot-rot of gram (*Cicer arietinum* L.) caused by *Operculella Padwickii* Nov. Gen. Nov. *Spec.*—*Indian J. Agric. Sci.* : 1941 : 316-318.

Krishna Iyer, P. V. . . . A Note on Analysis of a Special Complex Experiment. *Curr. Sci.* : 1940 : 0 : 533.

Krishna Iyer, P. V. . . . Standard Error of the Differences between Two Estimates for Incomplete Block Experiment. *Curr. Sci.* 1941 : 10 : 165.

Krishna Iyer, P. V. . . . The Analysis of Incomplete Split—Plot Designs. *Sci. & Cul.* 1941 : 6 : 487.

Krishna Iyer, P. V. . . . The Analysis of Simple Non-Symmetrical Experiments.—*Indian J. Agric. Sci.* 1940 : 10 : 686-690.

Krishna Iyer, P. V. and Sen, S. . A note on the Design and Analysis of Compact Experiments with three or Four restrictions—*Indian J. Agric. Sci.* : 1940 : 10 : 854-859.

Lal, K. B. (in collaboration with Hussain, A.) . . . . The Bionomics of *Empossca devastans* Distant on some varieties of cotton in the Punjab—*Indian J. Ent.* 1940 : 2 : 123-136.

Mani, M. S. . . . . Studies on Indian Parasitic Hymenoptera Part I.—*Indian J. Ent.* 1941 : 3 : 25-36.

Mehta, K. C. & Pal, B. P. . . Rust resistant wheats for India—*Nature*: 1940 : 146 : 98.

Menon, R. . . . . Studies on *Indian* Copeognatha (Pscocoptera) I.—Introduction, General morphology and classification.—*Indian J. Ent.* : 1941 : 3 : 13-23.

Mohan Singh, S. . . . . Household Insect Pests and their control, *Indian Farming* 2 : 6 : 1941.

Mundkur, B. B.	A second contribution towards a knowledge of Indian Ustilaginales. Fragments XXVI-L—*Trans. Brit. Mycol. Soc.* 1940 : 24 : 312-336.
Mundkur, B. B.	Some fungi from Afghanistan. *Kew. Bull.* No. 7 : 1940 : pp. 285-288.
Mundkur, B. B.	Are smuts poisonous ? *Indian Farming* 1940 : 1 : 358-359.
Narayanan, E. S.	Notes on some Indian Parasitic Hymenoptera with description of a new Cynipid.—*Indian J. Ent.* : 1941 : 3 : 59-63.
Narayanswami, S.	Megasporogenesis and the origin of Triploids in Saccharum.—*Indian J. Agric. Sci.* : 10 : 9 : 1940 534-553.
Padwick, G. W.	Virus diseases of plants.—*Indian Farming* 1940 : 1 : 501-503.
Padwick, G. W. & Uppal, B. N. .	The problem of Inter Provincial Plant Quarantines in India.—*Indian J. Agric. Sci.* 1940 : 10 : 697-706.
Padwick, G. W., Mitra, M. and Mehta, P. R.	The Genus *Fusarium* IV. Infection and cross-infection tests with isolates from cotton (*Gossypium* Sp.), piegeon pea (*Cajanus Cajan*) and Sann-hemp (*Crotalaria jumcea*). *Indian J. Agric. Sci.* : 1940 : 10 : 707-715.
Padwick, G. W.	The *Genusfusarium* V. *Fusarium Udum Butler, F. Vasinfectum* Atk. and *F. lateritium* Nees Var. *Uncinatum* Wr.—*Indian J. Agric. Sci.* 1940 : 10 : 863-878.
Pal, B. P.	Vernalization. *Proc. 3rd Meeting, Crops and Soil Wing. Board* of *Agric. and Animal Husbandry in India* 1939 : 125 : 31.
Pal, B. P., and Narayana Rao, T. .	Ovule mortality in gram (*Cicer arietinum*. L.). *Proc. Indian Acad. Sci.* 1940 : 12 : 50-61.
Pal, B. P. and Ramanujan, S. .	A new type of variegation in rice.—*Indian J. Agric. Sci.* 1941 : 11 : 170-76.
Pruthi, H. S.	Description of some new species of Empoasca from N. India.—*Indian J. Ent.* 1940 : 2 (I): 1-9.
Pruthi, H. S. and Mani, M. S. . .	Biological notes on Indian parasitic Chalcidoidea *I. C. A. R. Misc. Bull.* 30 : 1-49 pl. XXII, (1940).
Pruthi, H. S. and Samuel, C. K. .	Entomological Investigations on the Leaf-cure Disease of Tobacco in N. India IV. Some new alternate hosts of tobacco leaf-curl disease and the insect vector concerned.—*Indian J. Agric. Sci.* 1941 : 11 : 387: 409.
Ramanujan, S.	Autotriploidy in *toria* (*Brassica Campestris* L.) *Curr. Sci.* 1940 : 9 : 325-26.
Samuel, C. K. (in collaboration with Janjua, N. A.) . . .	Fruit Pests of Baluchistan.—*I. C. A. R. Misc. Bull.* 42 : 1-42. pl. iii (1941).
Venkataraman, T. S. . . .	An illustrated note on striga (a semi-parasite of sugarcane and its control).—*Indian Farming* 2 : 3 : pp. 142-143 : 1941.

Venkataraman, T. S., and Thuljaram Rao, J. . . . . Hard leaf mid-rib in sugarcane and resistance to top-borer.—*Curr. Sci.* 10 : 3 : March, 1941 : pp. 171-172.

Venkatàraman, T. S. . . . . Drought resistance in plants—Successful breeding results with the sugarcane.—*Proc. Indian Sci. Cong.* 1941.

Venkataraman, T. S. . . . . The need for exploration of wild forms in the improvement of crops.—*Proc. Indian Sci. Congress.* 1941.

Viswanath, B. . . . . Recent Developments in the Science of Plant and Animal Nutrition and their significance to National Nutrition and Health.—*Proc. Nat. Acad. Sci.* 1941.

Viswanath, B. . . . . A century of Liebig's theory of mineral nutrition of plants and of soil fertility.—*Curr. Sci.* : Vol. 9, No. 12.

Viswanath, B. . . . . All-India Soil Survey.—*Curr. Sci.* Vol. 10, No. 2.

Viswanath, B. . . . . A comparative study of the Methods of estimating the degree of unsaturation of soils. *Indian Soc.* of *Soil. Sci.*

Vyas, N. D. . . . . Do non-leguminous plants appropriate atmospheric nitrogen.—*Proc. Nat. Acad. Sci.*

GIPD—M636DIARI—5-8-42—430.